The Tradition of Making

Polder Cities

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Proefschrift

ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft,
op gezag van de Rector Magnificus prof. ir. K.C.A.M. Luyben,
voorzitter van het College voor Promoties,
in het openbaar te verdedigen op dinsdag 18 oktober 2011 om 12.30 uur
door Fernande Lucretia HOOIMEIJER
doctorandus in kunst- en cultuurwetenschappen
geboren te Capelle aan den IJssel

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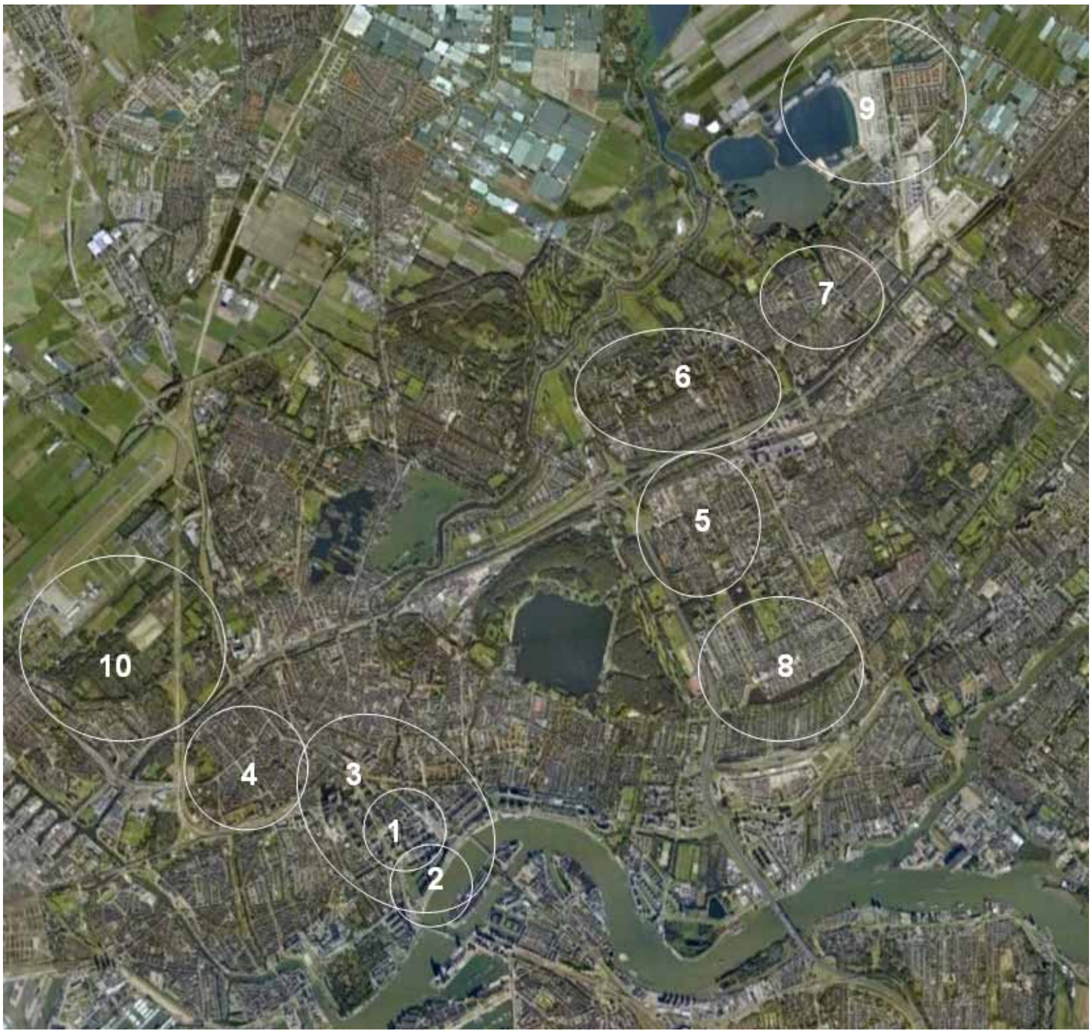
For Juri, August*, Otis & Grietje-Nel



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Content

Chapter 1: Polder Cities

> Cities are given shape by all sorts of people.
>
> They are shaped, for example, by military engineers – ships' gunners laid out the early British port cities of India – and by administrators and state officials – the oikists, leaders of the colonizing expeditions which gave us the Greek towns of Sicily. The mediaeval lords of England and France and Spain established hundreds of new towns or bastides in their territories. More recently the shape of cities has been greatly influenced by modern planning commissioners such as Robert Moses of New York and Edmund Bacon of Philadelphia. . . . A survey of this extraordinary group, their writings and the tools of their trade, will make a first-rate story.[1]

Introduction

This is the story of how Dutch polder cities have developed as hydrological constructions made by both civil engineers and urban designers, and how the relationships between these disciplines have changed. When it comes to hydrological engineering and spatial construction, the Dutch have a rich and internationally renowned tradition. Their expertise and knowledge of hydrological laws and ingenious technology have helped them to successfully make land out of water: polders.

> Polders are a special type of drained agricultural land typically found in low-lying coastal areas, river plains, shallow lakes, lagoons and upland depressions. Before impoldering, polder areas were either waterlogged or temporarily or permanently under water. An area becomes a polder when it is separated from the surrounding hydrological regime in such a way that its water level can be controlled independently of its surrounding regime. This condition is accomplished by various combinations of drainage canals and dikes.[2]

This also the story of the 'Fine Dutch Tradition', a term used by Steenbergen and Reh, that reflects on the old, unique and typical Dutch landscape architecture that – with a minimum of means – makes the landscape in which water is a crucial aspect useful and beautiful in a restrained and clear form.[3]

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[1] Kostov 1991, 11-12
[2] Luijendijk et al. 1988, 195-228
[3] The term 'Fine Dutch Tradition', is introduced by Henk Engel at the end of the 1970s in a booklet he made for an excursion to *Het oude Hof te Bergen* where he argued that the architecture was produced by that which is within the landscape. The statement reflects on the Dutch garden culture that played an important role in the wide spectrum of the Dutch culture around 1700. The garden architecture showed the mastering of the wet territory and difficult geography. The situation and size of the Dutch gardens demonstrated capabilities in water management, drainage technology and sluices. The appliance of drainage canals to geometrically divide and encircle the garden shows that Dutch gardeners were masters in combining horticulture, technology, water management and architectural design. See Steenbergen and Reh 2005, 7

However, can the term simply be hijacked for urbanism and can it be argued that the Dutch urban design is produced by that which is within the landscape? The 'Fine Dutch Tradition' is still a rather mystical term used to represent something not carefully studied in the urban context; a Systematic Analysis of urban development in relation to water management of the polder is lacking. It is ridiculous to believe polder cities developed randomly when land has been reclaimed, raised, drained and protected with so much effort.[4] Research on how this physical geography has changed and developed is lacking - particularly in terms of understanding how urban development evolved.

Knowledge and inspiration from this typical Dutch craft is required to resolve future urban challenges. The effects of urbanization on the hydrological cycle are now clear, especially since the climate appears to be impacting the larger hydrological cycle. The international climate panel (IPPC) has provided a scientific framework by claiming that climate change is due to human intervention in the natural systems.[5] In the Netherlands the Delta Commission has identified stormwater drainage as a major concern: the low-lying urbanized areas with impermeable surfaces and very little surface water are extremely vulnerable during heavy rain storms that occur more frequently.[6] The Delta program now has a department that focuses solely on establishing policy for stormwater in new urban developments and restructured urban areas. This emphasises the seriousness of this issue with urban design and planning that, as this research will show, is based on dealing with wet and soft soil and subsurface conditions typical within the Dutch territory. Therein also lies the importance of this research: to help evoke a cultural change.

Despite a strong connection to the larger-scale challange of flood management of rivers and rising sea levels, the research will focus on the urban scale and is primarily concerned with the regional-scale water system. The technical approach taken over the last century, this investigation will show, needs to be replaced by a spatial venture and this research will offer a Systematic Analysis as to how it has been done in the past and an analysis of this to find principles to apply into the future. Since the Dutch have an internationally renowned water management and urban design tradition and that climate change is a global concern, this investigation will be of interest on an international stage.

Dutch polder cities can be seen as a combination of what Kevin Lynch calls the "practical" and the "organic" models.[7] The Parctical Model, or the city as a "machine", is "factual", "functional" and "cool", not in the least bit "magical". It is the concept that motivates colonial cities and company cities, the grid cities of the USA, Le Corbusier's Radiant City, and, more recently still, the inventions of the British Archigram group and the arcologies of the American Italian Paolo Soleri. In the Netherlands it means dealing with the territory's wet and soft ground. The nineteenth-century engineering cities of Van Niftrik and Rose can be included in this category.

[4] Burke 1956, 65
[5] Adger et al. 2007, 717-743
[6] Deltacommissie 2008
[7] These are two of the three models he describes; the third model is the Cosmic Model. Lynch 1981

The Organic Model, or the biological city, sees the city as alive rather than as a machine. It has a definite boundary and an optimum size, a cohesive, indivisible internal structure and a rhythmic behaviour that seeks, in the face of inevitable change, to maintain a balanced state. The creators of cities according to this model are people such as Frederick Law Olmsted, Ebenezer Howard, Patrick Geddes and Lewis Mumford.[8] The dynamics of wet and soft territories are the context of the Organic Model found in Dutch polder cities.

The "magical" combination of these two models can be seen in the design of the polder city. The Parctical Model adapts to all hydrologic rules. The Organic Model is the blueprint of the social order: the social engagement of the people (engineers, surveyors and residents) who have to deal with both worlds. The making of Dutch polder cities, as Burke emphasizes, is not a matter of architecture alone, but primarily a visionary way of dealing with the hydrological demands of the wet territory:

> If Dutch town builders up to the seventeenth century were not brilliantly distinguished in the field of architectural achievement, they were second to none in the techniques of urban development. Their resourcefulness in the control of water and expert adaptation to building purposes of dreary and difficult sites need no further emphasis.[9]

He concludes that the *grachtenstad* (canal city) built under flood level is difficult to compare to other types and must be put in a class by itself.[10]

Unfortunately, to date this is all theory; an exhaustive survey into the relationship between the hydrology or the physical geography of the territory and the construction of Dutch cities has not yet been conducted. This is the objective of this research: to provide a Systematic Analysis of the development of polder cities and a critical review of conclusion drawn from the analysis. This will allow Dutch cities to be understood in terms of the relationships to water management and consider how the Fine Dutch Tradition can be extended effectively into the future. This will provide a base of knowledge upon which to work when tackling the current project of making cities water and climate proof.

Another reason for studying the development of polder cities and seeking a more precise definition of the Fine Dutch Tradition is that we seem to have discarded important components of the tradition since the Industrial Revolution. Webber and Rittel (1973) define 'tame' and 'wicked' problems, respectively being engineering and social tasks. The Industrial Revolution brings about professionalism and the domination of the idea of efficiency through machinery. This powerful idea becomes the guiding concept of civil engineering, aiding also to a dramatic change in urban design thus creating a rift between water management and the urban. Urban design is seen as a process of designing solutions to problems that might be undertaken and operated cheaply.[11]

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[8] Kostov 1991, 15
[9] Burke 1956, 163
[10] Burke 1956, 159
[11] Webber en Rittel 1973, 158

It is fairly easy to come to establish the nature of the problems that emerged in the early industrial period: water management can be assigned to the technically skilled, who in turn can be trusted to accomplish the simplified objective.[12] This classic paradigm of science and engineering has underlain modern professionalism, but is not applicable to problems of open societal systems.

> We shall want to suggest that the social professions are misled somewhere along the line into assuming they can be applied scientists – that they can solve problems in the way scientists can solve their sorts of problems.'[13]

Webber and Rittel define the problems that natural scientists deal with as 'tame' ones, the problem itself is clear and it is clear when the problem has been solved. In contrast, the urban designer deals with open societal systems and therefore 'wicked' problems, which have no clarifying traits. It is interesting for this story that Webber and Rittel make the connection to the military systems-approach, since that is one of the foundations of the discipline of urban design:

> The classical systems-approach of the military and the space programs is based on the assumption that a planning project can be organized into distinct phases: 'understand the problem or the mission', 'gather information', 'analyse the information', 'synthesize information and wait for the creative leap', 'work out solution' or the like. For wicked problems, however, this type of scheme does not work. One cannot understand the problem without knowing about its context . . .

Webber and Rittel mark the change, the end of the idea of efficiency, at the end of the 1970s when the urban context is reintroduced.[14]

This is an important notion since this idea of efficiency must have resonated with the pragmatic way polder cities are developed. It is interesting to see if the analysis of the polder cities will support this assumption and if it influences the character of the Fine Dutch Tradition.

These are the reasons to be interested in the development of polder cities, the definition of the Fine Dutch Tradition and the relation between the civil engineer and the urban designer today. The changing climate, ongoing urbanization, demographic and economic developments are putting pressure on existing polder cities. Developing more robust and resilient urban areas depend on stronger collaboration between these two disciplines responsible for creating polder cities. Greater understanding and awareness of the interrelation between the disciplines is necessary to develop urban conditions suitable for future 'climate proof' polder cities.

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[12] Webber en Rittel 1973, 158
[13] Webber en Rittel 1973, 160
[14] Webber en Rittel 1973, 155-169

Problem Statement, Hypothesis and Method

The problem statement for this study is formulated as follows:

> *Is there a Fine Dutch Tradition in urban design and planning and if so, how can it be defined and how was, will and could the interaction between urbanism and engineering be influenced by it?*

To be able to answer this question the urban development of polder cities will be studied (scale 1:1000 to 1:5000) in its relation to the urban water systems (of surface water in the polder and *boezem*[15] water, groundwater and storm water) and to the methods and technologies of building-site preparation. The urban development will be studied with the use of Rotterdam as the main case study. The technology of building-site preparation, as a method of dealing with building on a wet and soft soil and subsurface, is crucial for building polder cities. The research shall cover examples across the Netherlands but shall focus around Rotterdam, as it is an example of city that provides a living narrative of the technical evolution of Dutch water systems and a site that is overtly exposed to changing climatic conditions.

The hypothesis that guides this study is as follows: The Fine Dutch Tradition (in urban design and planning) is a type of dealing with urbanization that is based on a large coherence between the hydrological system, the soil conditions (as the objects of study of civil engineering) and the building of cities (urbanism). Part of this hypothesis is the assumption that civil engineering and urbanism developed hand in hand until the Industrial Revolution. The dramatic growth in scale introduced during the Industrial Revolution leads to the disciplines of civil engineering and urbanism becoming more professional and specialized. This segregates the disciplines and changes the perspective on which the Fine Dutch Tradition as an interdisciplinary approach is based.[16]

The second assumption is that the Fine Dutch Tradition is integral in Dutch urbanism, today and tomorrow, because it can lead to improvement in building attractive, waterproof and climate-resilient cities. The current debate in the transition from an industrial to a post-industrial city is, again, focussed on its aesthetic value. Strategies to make urban areas both attractive and safe are quite possible as this investigation will show. The Fine Dutch Tradition is not considered a paradigm but a richer and meaningful approach towards the natural system and urbanization.

Some Authors have made the connection with the Dutch preference for bringing order to the spatial circumstance of the wet and soft features of their territory, even without having a precise overview of what this Fine Dutch Tradition is. They see this as still being characteristic of Dutch urbanism: orderly, well-organized and with attention to beauty.[17]

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[15] Outlet waterway: the network of open water courses (and lakes) in a water management unit on a regional scale that serves as storage basin and drainage for the excess water from the polders and higher grounds.
[16] Also Calabrese (2004) comes to this conclusion in her research into mobility and urbanism.
[17] Hoogenberk 1968

Making a Systematic Analysis is the domain of architectural history, where aspects of the built environment and production process are studied. Kostof writes:

> We 'read' form correctly only to the extent that we are familiar with the precise cultural conditions that generated it. . . . The more we know about cultures, about the structure of society in various periods of history in different parts of the world, the better we are able to read their built environment.[18]

The architectural historian's method is based on that of art history (literature, archives and iconography), archaeology (maps and pictures) and the historical-critical method (insight in historical processes, objective scientific criteria, analyses and comments).

For this study a framework in time will be set up taking into account the history of technology and urbanism. This framework will be filled with more general information connected to the history of technology and urbanism through a study of the available literature. To be able to obtain insight into the practice of building-site preparation, a more detailed study of the archives is undertaken and interviews are held. In the following paragraphs the framework, the background of the study into building-site preparation and the choice for the case study Rotterdam are explained. The position of the project within other architecture-historical studies shall be noted at the end of this chapter.

Technological Development as Natural Order

A historical Systematic Analysis of polder cities can only be based on an interpretation of time in logical parts. These parts are called phases that represent a distinct stage of development that has a temporary attitude. These phases are of course indicative and will have shorter or larger transition times between them.

Rebecca Brown's study of the cumulative transition of Australian cities in relation to the water is an example of how a Systematic Analysis is used to make logical analyses and models. She presents a typology of six city states, namely the 'Water Supply City', the 'Sewered City', the 'Drained City', the 'Waterways City', the 'Water Cycle City', and the 'Water Sensitive City' (see picture 1.1). This framework recognizes the temporal ideological and technological contexts that cities undergo when moving towards sustainable urban water conditions.[19]

Brown's work is interesting offering insight into different city models that emerge from a certain period and context, offering a characteristic 'type' within time. Brown's use of the periods as a cumulative transitional state is not the idea of this analysis. But like Brown, this study uses the periods as signifiers, and considers them to be indicative of logic that is useful for the future.

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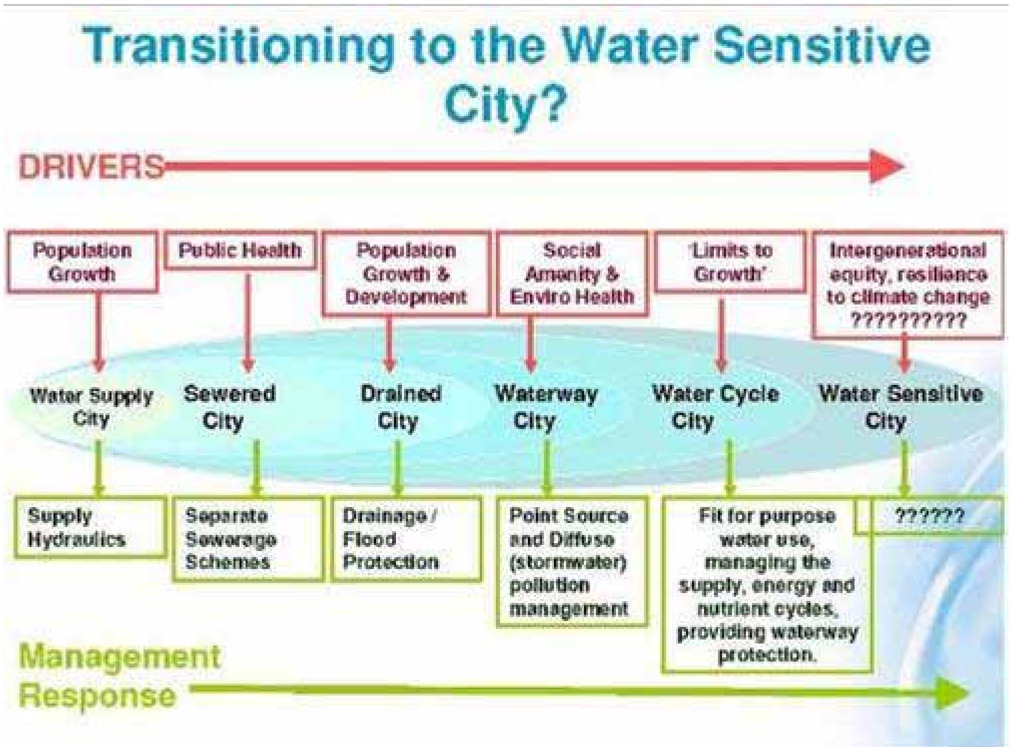
[18] Kostov 1991, 10
[19] Brown et al 2008



Picture 1.1 Brown's cumulative transition of Australian cities
Source: Brown 2008

This research touches on social and economic conditions and focuses on the territorial and technical circumstances as drivers of urban design. The territorial circumstances in the Netherlands are characterized by the dynamics of the regional water system, including groundwater and rainwater in combination with surface water, which in addition to the soft soil conditions is crucial for the process of development and urbanization of the Dutch polders.[20]

Willem van der Ham constructs a phasing for analysing the Dutch landscape on the basis of water-state historical criteria. He looks into the criteria used by Bijhouwer, *Het Nederlandse Landschap* (The Dutch landscape),[21] the *Atlas van Nederland* (Atlas of the Netherlands),[22] Van de Ven's *Manmade Lowlands*,[23] and *The Making of Dutch Landscape*, a historical geography of the Netherlands by Lambert,[24] and formulates the following Phases:

I. **Natural water state**: (until around 1000): Nature over culture, coast development, young dunes, thick peat layers, free rivers and wild grounds.

II. **Defensive water state:** (1000-1500) exploitation of the territory leads to means of protection, land loss, subsidence, sea and river dikes, mounds, dams, ditches, waterways, sluices.

[20] Sector Stadsontwikkeling Dienst der Publieke Werken, Amsterdam 1975, 67
[21] Bijhouwer 1977, 174-175
[22] De Atlas van Nederland 1987, 5-6
[23] Van de Ven 1993
[24] Lambert 1971

III. **Offensive water state:** (1500-1800): offensive diking, reclamations, windmills for pumping, large-scale land exploitation.

IV. **Manipulative water state:** (1800-present): intervention in systems (new river beds, definition of rivers, damming of larger waters, artificial water levels, loss of old structures).[25]

These Phases are all marked by a certain attitude and technology used in dealing with the wet circumstances of the Dutch territory. The ditch to drain the land to make it productive is used in the first Phase; the dike marks the Defensive Phase, the mill and the steam engine respectively of the Anticipative and Offensive Phase. The Manipulative Phase is a clear product of the Industrial Revolution that came with the induction engine and electricity.

However, for several reasons Van der Ham's phasing needs to be adjusted for this investigation. For one, because her study is built on water management and landscape perspectives only, while the urban, technology and water state history in this study bring about new perceptions.

To start with the latter, there has been additional research showing that the difference between the Defensive and Offensive Phases is not as well defined as Van der Ham would have it. In fact, according to Van Dam nothing really changed until 1800 (in the sense that more technology and control were developed but the people remained rather vulnerable) and the real change came with industrialization in the nineteenth century.[26]

She identifies the 'Amphibious Culture', the tradition of cultural adaptation to the specific landscape that is riddled with waterways: rivers, canals, ditches, lakes. Transport is by ship: every farmer and every city merchant is a shipper. The boat simply is the most important means of transport of the amphibious culture and allows amphibious behaviour, moving between wet and dry parts of the landscape. The landscape features are man-made, making use of the slight difference between sea level and average field level. The land is compartmentalized with interior dikes and many settlements are situated sufficiently high above the field level not to be flooded when dikes break. During flood disasters daily life is disrupted but people continue to operate in the half dry and half wet environment. Cities that stand out like islands are an important element of the dry parts. They provide the reserves for a restart of the more terrestrial life, including refuge for victims, labour, food, technological expertise, organizational capacity and financial capital.[27]

The work of Van der Ham and Van Dam is used to build a framework for this investigation that represents the attitude towards the natural system. This is different from the perspective of Van der Ham in that it takes the attitude of water management as its primary focus. For this framework the first three Phases (Natural, Defensive and Offensive) of Van der Ham are placed in the concept of Amphibious Culture to show that even though only the first Phase is called natural water management, this attitude

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[25] Van der Ham 2002, 29-31
[26] Van Dam 2010, 6
[27] Van Dam 2010, 6

also played a large part in the Phase of Defensive and Offensive water management. To avoid the idea that there is a marked distinction between the Phases of defence and offence (since Offensive is the opposite of Defensive) this Phase is renamed *anticipation*. As in the Defensive Phase the wet conditions are accepted and used to advantageously. What does change is that urban development becomes a considerable challenge due to urbanization. Instead of adding canals and filling in the parts between, technical plans for large-scale expansion are needed.

The period of Amphibious Culture coincides with the first stage in the history of urban design in the Netherlands, which is defined as the Early Modern Period (1500-1800).[28] This is a period in which urbanization started (in 1500 5 per cent of Europeans lived in cities and in 1800 10 per cent) leading to concepts like capitalism, national states and the Reformation. It is characterized by the pre-industrial society.

Around 1800 the Amphibious Culture and the Early Modern Period end and the beginning of the industrialized society emerges. The Industrial Revolution (in the Netherlands from 1850 to 1890) marks a major turning point in human history; almost every aspect of daily life is eventually influenced in some way. This is when Van der Ham's Manipulative Phase starts, to continue to the present. In relation to the development of technology, the development of the disciplines civil engineering and urban design, and considering urban history, this period is rather long. It represents what comes after the Amphibious Culture - which can be called Land Culture, aiming at transport by land (train and later car), requiring that the land stays dry, and eventually making water a redundant urban element. Scientific history shows that after 1890 civil engineering and urban design professionalize. Again, the introduction of a new (stronger and accelerating) power after the Industrial Revolution drastically changes urbanization.

For this research the term Land Culture is used as an umbrella term for what Van der Ham defines as the Phase of Manipulative water management. In urban history the Early Modern Period is followed by the Modern Period (nineteenth century) and Modernization (twentieth century). That is a reason to divide Van der Ham's Manipulative Phase into three parts. According to the availability of technology the first part of the Manipulative Phase is called the 'Offensive' attitude towards the natural system despite potential confusion with Van der Ham's use of the term for the earlier Anticipative Phase. This Phase starts with the steam engine (around 1800) and ending with the combustion engine (diesel, petrol), electricity (around 1890), this also covers the urban stage of the Modern Period. Offensive is a better term for this era since it is a period characterised by taking control, and a shift in the perspective from the natural system to the cultural system as will be explained in chapter four.

For the period between 1890 and 1990 Van der Ham's term Manipulative water management is maintained. It is consistent with the urban stage of Modernization, which ends in the 1970s. Hereafter the architectural world uses the term "postmodernism" to define the transition from modernism. Fredric Jameson writes:

[28] See: De Vries (1997) and Taverne (1978)

> Postmodernism is what you have when the modernization process is complete and nature is gone for good. It is a more fully human world than the older one, but one in which 'culture' has become a veritable 'second nature'.[29]

This post-industrial society and for the remainder of the time into the future the Phase is called the 'Adaptive Manipulative' attitude which emerges in the 1990s.

Table 1.1 The research framework

Industrial Revolution in the Netherlands

Year	-1500	1500-1800	1800-1890	1890-1990	1990-
Urban History		Early Modern Period (De Vries)	Modern Period (Van der Woud)	Modernization (interwar, post-war, 1970s)	Post-Modernism (Jameson)
Society	Pre-Industrial		Industrial		Post-Industrial
Marking Technology	Ditch, Sluice, Mound, Dike	Mill	Steam	Combustion engine (diesel, petrol), Electricity	Computer
Brown			Water Supply City'	Sewered city Drained City Waterways City	Water Cycle City Sensitive City
Van der Ham	Nature & Defence	Offensive	Manipulative		
Van Dam	AMPHIBIOUS CULTURE				
Hooimeijer			LAND CULTURE		
Hooimeijer	Nature & Defence	Anticipative	Offensive	Manipulative	Adaptive Manipulative
Chapter Title	Natural Power	The Power of Unity	The New Power	Accelerating Powers	Adaptive Power

Accelerating Machine Power 1890-1945	Accelerating Manpower 1945-1970	Accelerating Flower Power 1970-1990

[29] Jameson 1991, IX

The fact that this study looks into this large timeframe, as projected in table 1.1, has two consequences. First, the research can only make use of primary sources up to a certain point and will make use of examples that have already been studied for other purposes. The importance of making a Systematic Analysis, therefore, is chosen rather than developing new material. Second, with a systematic analysis it will be possible to find the red threat – the continuity and fundamental characteristics - in the development of the Dutch approach to see if the Fine Dutch Tradition is evident in the urban context.

This dissertation is ordered into chapters that each represents a Phase. Each chapter starts with the introduction of urban development, technology and the professional background of the city builders. After outlining the general developments and characteristics of that time period, a project in Rotterdam is used as case for that specific time and development to show how the territorial and technical conditions influence the urban design (or not). The connection to other projects in the Netherlands of that period and the more general developments of building-site preparation are interwoven into the story of Rotterdam.

The projects will be evaluated on their current performance based on Rotterdam's water management using the information given in the *Waterplan 2* (2007).

The conclusion of each chapter describes the episode of the Fine Dutch Tradition that is connected to the specific Phase. The Fine Dutch Tradition is not broken up into Phases but into episodes to emphasize that it is a tradition in a certain approach and therefore continuous. During the Manipulative Phase there are three episodes of the Fine Dutch Tradition as a result of the developing domains of engineering and urbanism.

Besides the archival research (in the Public Works archive) per project – per Phase – to connect the technology to the urban development through words and image, each project will be subjected to an analysis of urban ensembles (buildings, public space and infrastructure), an examination of its relation to the original landscape structure, and of the relation of the methods of building-site preparation that are used to implement the urban design. Since these projects exist (except for the city centre) these can be evaluated on their current state. Do these areas have problems with water and how are they dealt with?

The chapter about the Manipulative Phase (1890-1990) is divided into four parts because of the size and content. Chapter five introduces the relation between the disciplines, the general urban developments and the history of building-site preparation of the Manipulative Phase. Due to the fact that there are very different urban types recognizable in this Phase, subchapters are dedicated to each of these: 5a *Accelerating Machine Power* (1890-1940), 5b *Accelerating Manpower* (1940-1970) and 5c *Accelerating Flower Power* (1970s).

Each chapter, and Phase, shall contribute to a better view of the Dutch approach in urbanizing the wet and soft territory. This will be more extensively analysed in chapter seven and a definition of the Fine Dutch Tradition will be given in the conclusions.

Building-Site Preparation

> Building-site preparation is the science of matching the location of the projected urban features to the soil and water conditions and the technique of making those conditions suitable for urban projects.[30]

The most important soil and water conditions taken into consideration when applying building-site preparation are load-bearing capacity, compressibility, permeability, moisture retention capacity, drainage and growing environment.[31]

This definition is the door to several fields of knowledge, a large number of activities, stakeholders, time and money. For these reasons one expects to find a lot of writing, debate and an expanding body of knowledge. However, building-site preparation has never brought all knowledge and stakeholders together; the practice in the Netherlands has always been divided between the stakeholders and the fields of knowledge on which it has been built.

Also, specific to the Dutch situation is that many technological aspects of hydrologic development enabling building on wet and soft ground have never been subjected to study nor been described in literature. The Dutch consider their country and language group to be very small and do not think it is important to make a written record of these matters, which their fellow countrymen are expected to know intrinsically from birth.[32]

The number of formal publications about building-site preparation is one: *Bouwrijp maken van terreinen* (Building-site preparation) by Segeren and Hengeveld, published in 1984. This book is the result of the accumulation of knowledge developed for constructing the new towns in the IJsselmeerpolders (Lelystad, Almere) and large urban extensions of the 1970s such as Zoetermeer and Purmerend. Besides this book, Segeren and Hengeveld also prepared syllabi for their course in 'polders' at Delft University of Technology, Faculty of Civil Engineering and Geo Science, and authored a few other reports.[33] Some of the work is updated and made available for urbanist students by Prof. dr.ir. Taeke de Jong (Faculty of Architecture, department of Urbanism).[34]

Additional material used as a basis for the writing about the history of building-site preparation is extensive. More specific articles published in the journal *De Ingenieur* (1884-2008), various reports written by a number of institutions such as *Onderzoek naar de wijze van bouwrijp maken van terreinen in een twaalftal gemeenten in Nederland* (Research into methods of building-site preparation in twelve municipalities in the Netherlands) by the IJsselmeerpolders Development Authority (1977) and *Invloed van de verstedelijking op de waterhuishouding in West–Nederland* (The influence of urbanization on the water management in the western Netherlands) by the

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[30] The definition by Segeren and Hengeveld 1984, 12
[31] Segeren and Hengevel 1984, 43-44
[32] *De Ingenieur* (1914), 261
[33] E.g. Rijksdienst voor de IJsselmeerpolders 1981; Sturm 1982; Grontmij 1980; Luyendijk 1975, Gemeentewerken Rotterdam 1968; Anonymus 1982
[34] De Jong 2008

group Polder at Delft University of Technology and David Biron's Master's thesis *Beter bouw- en woonrijp maken* (Better building-site preparation) written in 2004.

Biron also remarks on the shortage of literature on the subject, and he sees the cause as the wide range of expertise concerned with building-site preparation. He proposes a new and up-to-date version of Segeren and Hengeveld's 'bible'.[35]

Besides defining what building-site preparation is, Segeren and Hengeveld also sum up the activities considered to be part of building-site preparations: clearing the site, filling or excavating the site, excavation for water structure, drainage system, sewer, construction of civil water works (bridges, tunnels, pumps), road pavement, soil improvement for green structures, cables and pipes, street furniture.

Hydrological interventions involve: filling the site, drainage (surface, sewer and groundwater), discharge, soil improvement, water supply, wastewater collection and treatment.

Geotechnical actions are the improvement of the load-bearing capacity and the reduction of land subsidence, together with the improvement of conditions for plants and trees. The decisive aspects for building site preparation are the original soil conditions, the water system, the urban design and the type of sewer.[36]

The history of building-site preparation and the way it developed over the centuries has never been documented, for the reasons described above.[37] When writing this history a specific framework is required in order to keep the project within a reasonable size. For this research the foundation is provided by the magazine *De Ingenieur* (1884-2008) where the articles can be viewed chronologically. Added to this are some basic works in soil mechanics: A. Verruijt, *Soil Mechanics* (2001) and W.J.M. de Vet, *Geotechnische apparatuur in Nederland 1850-1975. Een inventarisatie-onderzoek van industrieel erfgoed uit de branche grondmechanica en funderingstechniek* (1994) (Geotechnical instruments in the Netherlands 1850-1975. An inventory of industrial heritage in the field of soil mechanics and foundation technology).

Rotterdam

Lewis Mumford uses the Amsterdam *Grachtengordel* to illustrate his theory about the relation between town planning and the specific conditions in which they are built.[38] In *Culture of Cities* he defines the specific regional conditions in geographical qualities (soil conditions, climate, vegetation, agriculture, technical exploitation) and the existence of a dynamic balance with the region. Here he puts the connection between social and geographical aspects as the main motive to study history as a perspective for the future:

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[35] Biron 2004, 10-11
[36] Segeren and Hengeveld 1984, 22-23
[37] Segeren and Hengeveld 1984, 23
[38] Mumford 1938, 500-505

> Without a long running start in history, we shall not have the momentum needed, in our own consciousness, to take a sufficiently bold leap into the future.[39]

Social behaviour determines history within the given conditions of the region. In the Dutch case the wet and soft soil conditions created a collective enemy resulting in a strong feeling of citizenship and powerful tradition in water management expressed in the very early installation of a public body in the form of the Water Boards. How the Dutch approach the geographical circumstances is related to social, economic and technical relationships and results in very specific city form. The subject of this study is the first of its kind. It will show that the balance between the social, economic and technical relationships produces a new city type.

For this research Rotterdam is used as the case study to analyse the relationships for each of the defined Phases. As the second largest city in the Netherlands, built in peat polders along a major river, Rotterdam represents the urban history of the Netherlands. In other words every period in the history of urban design is found in the urban layout of Rotterdam.

Another reason to choose Rotterdam is because it has also been in the forefront of technological development; in this respect Rotterdam is exceptional and not exemplary. Rotterdam is a city where from the start technology is used intensively to design the cityscape. The polders, the peat lands, the Maas River are all 'natural' artefacts that need to be controlled by engineering to be useful for urban occupation. Rotterdam has always had a progressive attitude towards the engineering of these artefacts and later on used this modernity as a promotional aspect of the city.[40] In the eighteenth century it is the first city to carry out trial-and-error research on steam engines, and in the 1950s the Department of Public Works is a leader in the development of geotechnology.

The 1985 report *Methoden van bouw- en woonrijpmaken in Rotterdam* (Methods of Building and Housing Construction in Rotterdam) states that the situation of the site and the soil and water conditions need to be adjusted to the demands that come with new spatial development. The other starting point is that the spatial functions should be situated on locations where the soil and water systems are suitable: soil condition assessments are carried out, but an assessment of the water control has never been a part of the land policy of the municipality of Rotterdam.[41] The only information about the development of the city and its engineering (in 1984) is *Rotterdam in de negentiende eeuw* (Rotterdam in the nineteenth century) by L.J.C.J. van Ravesteijn.[42] He describes the *Waterproject* 1854, the expansions on the south side and the report *Inzake het vraagstuk van de grondwaterstand te Rotterdam* (Concerning the groundwater level in Rotterdam) of 1919.

Now the city again finds itself confronted with new threats. Climate change and rising sea levels may eventually have an impact on Rotterdam's position. Socioeconomic processes can also enter a downward spiral,

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[39] Mumford 1961, 11
[40] Moscoviter 1996, 27
[41] Gemeentewerken Rotterdam 1984, 10
[42] Van Ravesteyn 1924

especially if the vulnerable position deters companies from locating in the city. Together with problems concerning housing, urban decline, social segregation and a traffic network that is coming to a standstill, the result is a sombre future scenario. Assertive in nature, the city develops its progressive *Waterplan* 2 (2007) and the *Waterstad 2035* (2005) plan showing its intention to have urban design and engineering working more cooperatively towards a sustainable city. Also, Rotterdam is chosen as the 'hot spot' for the development of knowledge and practice by the research programme 'Kennis voor Klimaat' (knowledge for climate). This programme brings public and private partners together and develops pilots in making cities climate proof.

Since Rotterdam operates on the technological frontier and represents the history of urban developments, it offers a clear view of the relation between civil engineering and urbanism. This is one of the most important aims of this research. Of course there are other examples in the rest of the Netherlands that offer a varied view of the relationship between civil engineering and urbanism and other urban designs. These examples will be integrated and used as a reference in this story about polder cities, but not investigated in the same detail as the Rotterdam examples.

Project Position

It is quite natural that this research sits within the department of Urbanism at the University of Technology in Delft. In the chair of Urban Compositions research is done into the groundworks of the discipline of urban design - where this research also aims to contribute. The work of Calabrese (2004) also covers the relation between design and technology, but focusing on mobility. She considers a marriage necessary for meaningfull development. In relation to urbanism and water the work by Meyer defines the position of this project. Meyer's dissertation named Harbour and City consideres the formal relationship water and city. Since this research he continued specilizing in the subject and has developed a view on what he calls Delta Urbanims, more specifically applied to his work for New Orleans. Both Meyer and Calabrese are urbanists theorisng about the discipline and forming the academic background of this project.[43]

Due to the dual character of this study, one side based in urban history and the other in the history of technology, the literature studied has been focused on both fields. This part of the research forms the base for the longer lines of the study and is also aimed at finding stories that illustrate the relation between urbanism and engineering. The main objective of this project, naturally, is the study how both relate. Literature in which water is considered to be the motivation for Dutch urban design, or where the newly-developed technology is connected to urban development, is hardly available, hence the need for this study.

As the introduction to this dissertation already stated, no Systematic Analysis of the relation between urban development and water management

[43] Calabrese 2004, Meyer 1999 and 2010

has ever been made. Somehow the wet conditions have been taken for granted and only the organizational, formal and design structures of the Dutch cities have been studied in urbanism, while engineers studied urban run-off processes, waste water treatment and geotechnical and structural engineering problems.

In the field of urban history this research is positioned among literature in which the relation between water technology and urbanism has more or less been the non-explicit object of study. Two types are distinguishable: the specifically architectural-history research or the study into urban form. The architectural-history studies are Van der Woud (1987) *Het lege land*, Taverne (1978) *In 't land van belofte* and Abrahamse (2010) *De grote uitleg van Amsterdam*. In all three the relation between urbanism and dealing with wet and soft soil conditions remains implicit and self-evident. Taverne and Abrahamse offer a lot of insight into the Phase of the Anticipative attitude towards the natural system. Van der Woud does the same for the Offensive Phase and also offers an interesting line of reasoning that is very important to this investigation, namely the concept of *longue durée*. This concept is created by Fernand Braudel (1902-1985) who wrote *La Méditerranée et le Monde Méditerranée á L'Epoque de Philippe II (1949)* (The Mediterranean and the Mediterranean World in the Age of Philip II).[44] Braudel is famous for his vast panoramic view and the use of insights from other social sciences. The concept of the *longue durée* is the first of three time levels. The first involves the geographical/environmental time, with its slow, almost imperceptible change, its repetition and cycles wherein change is irresistible. The second level of time comprises social and cultural history and the third level that of events, respectively fast and fastest. It greatly resembles the layer approach that is used in spatial planning but strictly in its temporal dimension.[45]

The *longue durée* is an important concept when studying the hydrological and geotechnical system and therefore the logic of making a Systematic Analysis, as this investigation aspires, needs to relate to this concept. This concept is also a central point of view used for the publication that belongs to the type studying urban form: Palmboom's *Verstedelijkt Landschap* (1987) and *Drawing the ground, layering time* (2010). Palmboom shows that the characteristics of the *longue durée* of the Rotterdam area and urban design in the Netherlands make the relation between urbanism and the natural conditions explicit. The work by Palmboom takes place in and represents the Phase of Adaptive Manipulation and connects to the contemporary movement of Landscape Urbanism.[46]

The last two publications upon which this investigation builds are Burke

[44] Van der Woud 1987, 16

[45] The layers approach was developed by a group of urbanists and landscape architects as a conceptual framework to guide Dutch spatial policy. The original approach distinguishes three types of connected layers characterized by different rates and types of (potential) spatial development and change. The lowest and slowest layer is represented by the subsurface layer (soil, water, nature, landscape) that consists of longstanding structures that are difficult to change. The middle layer corresponds to the network layer (infrastructure) that represents large-scale civil structures that can be changed but still at a low rate and often involving high costs. The upper and fastest layer is the occupation layer (living and working) that represents the (use of) buildings with a relatively high rate of change (dRO Amsterdam 1996; Hoog, Sijmons en Verschuuren 1998).

[46] There are actually two movements of Landscape Urbanism. One of

The Making of Dutch Towns (1956) and Van Eesteren *Algemeen Uitbreidings Plan* (1934), which both make the relation between water management and urban design very explicit. Burke is an important source and way of thinking for the Phases up to the Anticipative attitude and Van Eesteren marks the transition towards the most segeragated situation of civil engineering and urban design.

There is only one book from the field of technology that considers city design and the land and water issue. This is Segeren and Hengeveld's 'bible', *Building-site preparation* (1984) mentioned earlier, that has been used extensively for this study.[47] In their introduction they give an overview of the relation between building-site preparation and urbanism that has been crucial for this study and also give preliminary conclusions that are tested in this research.

Another important title is *Manmade Lowlands* written by Gerard van de Ven, which introduces the history of the man-made lowlands and the hydrological constructions in the landscape.[48] This book sets out the basis for landscape development and technological development, but does not make the link to urban development on the scale of urban design. The same applies to the article in *Waterscapes* by Willem van der Ham, 'History', which connects the landscape and technology to the human attitude towards water and lays the foundations for the phasing that is the basic structure of this research.[49]

The position of this research is, as is its character, dual in the sense that it lies between different fields of knowledge. It uses the methods of architectural and historical research – the heuristic method of finding experience-based techniques for problem solving, learning, and discovery – but because this study tries to fill a large void it will not be as detailed as the studies done by Abrahamse and Van der Woud. These two studies, however, offer considerable material for chapters three and four, respectively 'The Power of Unity 1500-1800' (Abrahamse) and 'The New Power 1800-1890' (Van der Woud). As Van Eesteren illustrated the context of the Manipulative Phase (chapter five) so Palmboom marks the change towards adaptive power.[50]

This study aspires to be more than the successor to Gerald L. Burke's study in formulating the relation between the characteristics of the territory and urban development. While Burke – possibly because his period of study is so long and because of his lack of understanding of the Dutch language – takes only formal, morphological aspects as the core of his investigation, this research also uses written sources and a broader context of the history of technology to explain the urban patterns. The combination of these sources produces new insight into the development of polder cities. This research overlaps with *The Making of Dutch Towns* until the seventeenth century and then concentrates on the development of the polder city, and leaves the development of the coast and river cities unaddressed.

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[47] Segeren and Hengeveld 1984
[48] Van der Ven 1993
[49] Van der Ham 2002
[50] Palmboom 1987

It is curious and interesting as to why water historians have their focus either on the larger scale of the landscape, or the smallest scale, the water construction artefacts. The social scale of water management is also their domain. Urban historians tend to leave out the history of technology all together. Then there are the historians of technology, who do not make the connection to the design of cities and landscapes at all. Their work is gratefully used for this research. It is difficult to position this research within that of the history of technology since that is so widespread and different in character.

This research hopes to fill the void by expanding the work of the water historians to the urban scale and building-site preparation, adding the history of technology to urban history and introducing the design of cities and landscapes to the world of technological history. The collaboration by landscape architects, civil engineers and urban designers of producing the *Atlas of Dutch Water Cities* (2005) is a first step in filling the gap; this is done for river, coast and polder cities. This project concentrates only on the polder cities.

Besides these ambitious objectives this investigation's aim is to introduce historical research as crucial for the future development of cities in general and for building in wet and soft circumstances specifically. It will provide common ground for urban designers and civil engineers to work together on the complexity of cities today. As far as building in wet and soft territories is concerned: the hydrological system is like a time machine that keeps up with history and that will continue to shape the cities of the future.

Chapter 2 Natural Power (-1500)

The Dutch Territory and Settlements

Until the eight century, the Dutch lowlands are uninhabitable marshlands where the forces of water and wind have free reign. How people deal with the wet surroundings is by accepting the existing situation and adapting ways of living with it. Van Ham describes this period of time until the year 1000 as being distinguished by 'natural water management', as nature rules over culture.[51] There are small initiatives to control the natural landscape by digging drainage ditches that allow crops to grow in the fields, but for the people living in the lower Delta there are no means of protection from the water.

Some technology is introduced by the Romans who conquered and occupied the Dutch Delta for about 400 years until the third century. The Romans stabilize their bridges on the wet and weak grounds by using piles. They also introduce the wooden sluice, which comes into use more commonly around the year 900.[52]

The first forms of preparation for building sites are the construction in Friesland, from 900 AC, of artificial dwelling mounds intended as refuges in times of high tides.

For this Phase (and the next) the publication of Gerald L. Burke, *The Making of Dutch Towns* is a main source.[53] He describes how most settlements in the Netherlands start on higher ground, along rivers, on the sandy ridges at the coast and on *geestgrond* (firm ground comprising a combination of clay, peat and archaic sand dunes; suitable for building development). Settlements expand in the eighth and ninth centuries for military, and later economic, reasons. Towns, or, more accurately, villages, are created on economic routes and military boundary lines.

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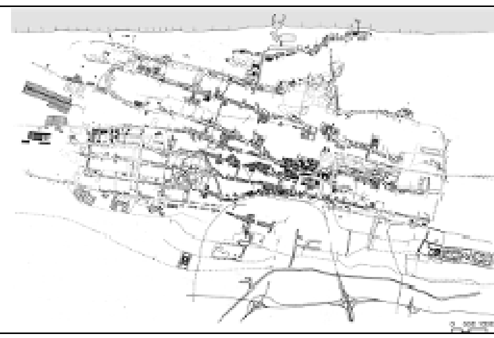
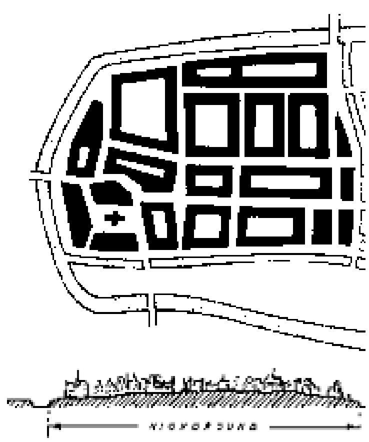
[51] Van der Ham 2002

[52] Arends 1994, 12 and De Vet 1994, 3

[53] In 1956 Gerald Louis Burke, Fellow of Royal Institution of Chartered Surveyors in the UK, publishes his study *The Making of Dutch Towns, A Study of Urban Development from the Tenth to the Seventeenth Centuries*. Burke writes in his preface 'that the book represents an attempt at exploration of ground already well covered by Dutchmen', apparently unaware that his study is the first and only one for a long time. In his book he sets out an urban typology of Dutch towns between the tenth and the seventeenth centuries. The idea for the book, which is the dissertation for his Master's of Science in Estate Management at the University of London, came to Burke when he attended summer courses on 'Culture of Cities and Civilization and Modern Society' at the University of Leiden in 1947 and 1948. Besides many institutes he thanks Sam van Embden (urban designer and owner of the office OD205) and Fockema Andreae (writer of important Dutch works about urban design and planning) in his acknowledgments.

Table 2.1 Towns in the Natural Phase, accepting attitude towards nature

Artificial dwelling mound -Not necessarily close to open water -Church and houses are situated according to the shape of the mound Source: Hooimeijer 2005	
River (Kampen) -Close to the water, the water is not necessarily part of the urban tissue -Buildings are oriented towards water and road structures Source: Jacob van Deventer	
Coast (The Hague) -Close to the water, the water is not part of the urban tissue -Roads and buildings are situated on stable sand ridges along the coast, shaping the urban tissue Source: Heeling 2002	
Geestgrond (Alkmaar) -Close to the water, the water is not part of the urban tissue -Buildings and the roads situated according to the shape of the landscape structure Source: Burke 1956	

The Hansa towns of Deventer, Kampen and Stavoren and the centres in Dordrecht and Tiel are built on the intersections of waterways. Deventer is the first city where the land touches the IJssel on the east. Amersfoort, Coevorden and Groningen develop at the intersections of lanes on dry land. Groningen is at the end of the road over the Hondsrug and at the beginning of a good water connection. Coevorden is situated on the sandy ridge that connects the Northern provinces with Germany through impassable areas of peat. River towns such as Maastricht, Nijmegen, Utrecht and Vechten benefit commercially from the proximity of the water.[54]

The original aorta of Holland is the Rijnweg or Heerweg, a road on 'terra firma' over the dunes along which the cities The Hague, Voorburg, Haarlem and Alkmaar develop. Arnhem, Harderwijk and Rotterdam are built at the convergence of roads and waterways.[55]

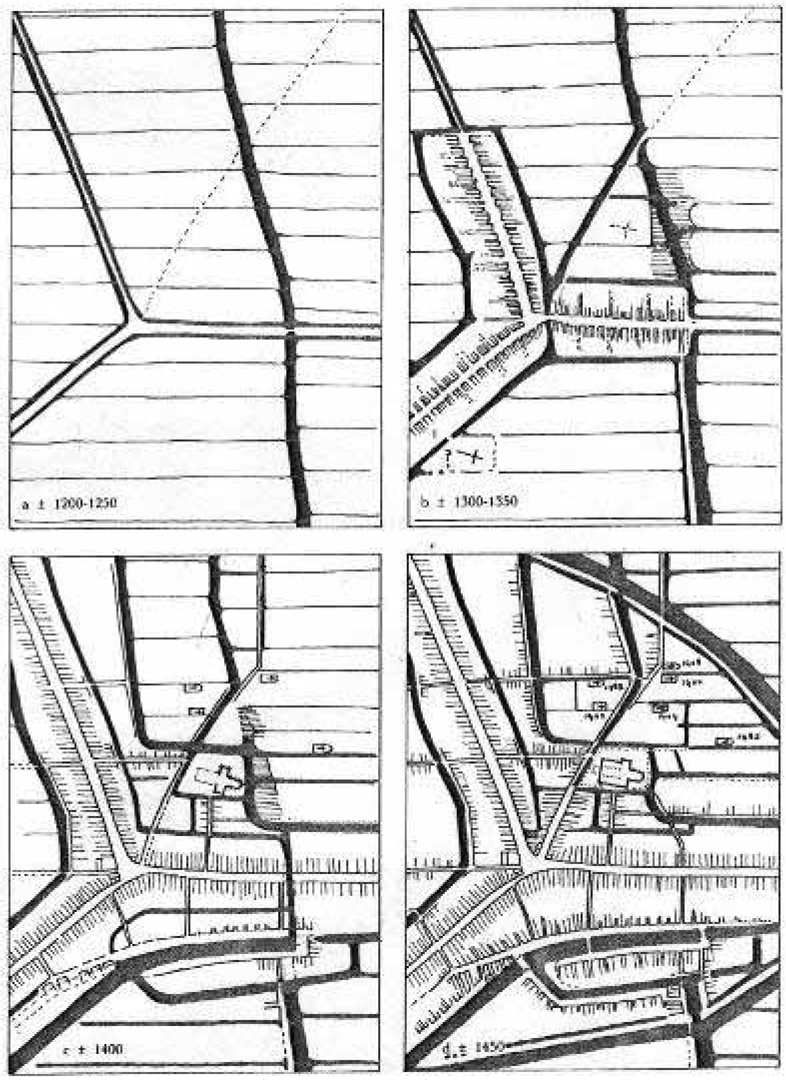
The physical characteristics of the settlements during the time of natural, accepting attitude towards nature have two important spatial features. In the first place, the situation of the settlements takes into account the most geographically convenient physical circumstances in the region. Second, in the case of a large river the location must be close to the water, but the water is not part of the layout of the settlement (since that would make the settlement more vulnerable). In the case of the polder water system the development is interwoven with the water system like in Hoorn, see picture 2.1.

Van Ham places the change in attitude from natural, accepting attitude towards nature to Defensive around the year 1000, when the dike is introduced as means of protection.[56] This new technology directly affected the location and establishment of settlements (see table 2.2). The situation of the settlements and their physical-geographical circumstances can be altered to facilitate living and the dike enabled water, in the form of a harbour, to be introduced into the settlement. Many dike and dam cities are set up in the thirteenth and fourteenth centuries and the sites are prepared for building by filling them with debris. For example, in the Middle Ages Dordrecht expands into the 8-m-deep river by filling it in; the same goes for Hoorn, Alkmaar and Enkhuizen.[57] *Burcht*s – castle, citadel, stronghold - are built using the same technology – not to defend the city from the water but for military protection. Examples of towns that flourish because of their location on a military boundary are the *burcht* towns of Leiden, Middelburg, Oostburg, Den Burg, Doesburg and Breda.

The most famous example of a dam city is, of course, Amsterdam. Until 1940 the inhabitants of Amsterdam continue to raise their city to prevent flooding, up to the level of 0.70 +MSL.[58] The dam is built in the twelfth century and starts the urbanization system of digging canals for drainage, transport and the provision of mud with which to raise the living areas (as

[54] See Rutte 2002; also in the department of architecture at the faculty of Architecture (TUD) morphological research is done into this timeframe with interesting studies like The ideal Model and the Project. Rethinking Urban Architecture. by Henk Engel and Urbanisation patterns in the Randstad by Drs. Nikki Brand.
[55] See for more insight in these basic types of water cities Burke 1956, Hooimeijer et al. 2005, Hooimeijer et al. 2008 and Segeren and Hengeveld 1984, 24
[56] Van der Ham 2002
[57] See for the background of this Segeren and Hengeveld 1984, 25; Sarfatij 1972, 620-627, 659-667; Petri 1913; Cordfunke 1973; Visser 1964
[58] Segeren and Hengeveld 1984, 2; and Dienst Openbare Werken Amsterdam 1974

mounds did). Houses are built along these canals with streets on either or both sides in quite a high density. A common characteristic is that they are relatively narrow and deep, as they all needed access to the (raised) street.[59]



Picture 2.1 Development of Hoorn during four Phases.
Source: Wiersma 1981

After the building of dikes for protection from the river, filling the grounds for the realization of the freeboard and at the same time to strengthen the wet, soft soil, and then after the building of foundations under buildings, people can build their houses and layout their streets. The earliest technology for the foundation of houses on wet and weak soil is introduced by the founding fishermen of Amsterdam in the thirteenth century, who build their houses on wooden rafts, the forerunners of piles.[60] Under the house walls ditches are dug into which two parallel oak beams are placed. Between the beams small piles are driven into the ground. As will be described below, in Rotterdam they develop their own distinctive type, while

[59] Janse 1993, 5-8
[60] That are used by Romans earlier for the stabilization of bridges but were not used in the private development of houses.

building on the same type of peaty soil.

Until about 1500, most dwellings are built directly on the ground, while churches and larger public buildings are built on small piles. The transition from wooden to stone houses in the sixteenth century means that most houses need a foundation to cope with the pressure that the weight of the houses puts on the weak soil.[61]

The period from about 1000 to 1500 is referred to as that of the 'great reclamation' of agricultural land. The windmill is widely introduced for drainage. Water from ditches surrounding individual properties is discharged into peat streams and thence into rivers. This laid out the landscape in regular patterns and standard measures.

In the twelfth century discharging water becomes difficult, partly due to the silting up of the Rhine, the main river. The discharge is restored by digging new channels and building dams and sluices to control the water. The cooperation and organization needed for public projects of this sort leads to one of the oldest forms of local government, the 'Water Boards'.[62]

However, the improvement in reclamation techniques does not lead to the amassing of agricultural land due to the counter effect of the discovery that dried peat can be used as fuel. Peat is mined on a large scale during the Middle Ages and the twelfth century. At first a thin layer is removed from the top, but with the invention of a manual dredge deeper digging is made possible.

This results in the formation of a landscape with walls and lakes that is very vulnerable to storms and subsidence, and consequently a lot of reclaimed land is lost to the lakes that flood the surrounding area when storms breach the walls. In this vulnerable landscape the settlements situated on natural elevations or on dikes are also the targets of natural forces. The people living in these areas become accustomed to these forces. Their flexible attitude, resulting in a natural, accepting and Defensive attitude towards nature, enables them to adapt to the circumstances and make their territory liveable.[63]

Until the eleventh and twelfth centuries, houses are made of wood and only cloisters and churches are built of stone. Complex constructions in Roman and Gothic styles significantly develop the knowledge of building and construction, making such knowledge elite and its possessors people of importance. Experienced builders, carpenters and bricklayers travel around to help build cloisters and churches in many places. They are organized in guilds and have great influence in the economic and political sectors. They work as city architects and together with the city surveyor formulate the plans for expansions.[64] Since the fourteenth century surveyors have been the specialists in dividing private from public ownership, thus making it possible to resolve property issues.[65] These city builders develop knowledge through experience, accepting errors and working with successful solutions without a scientific explanation as to why they work.

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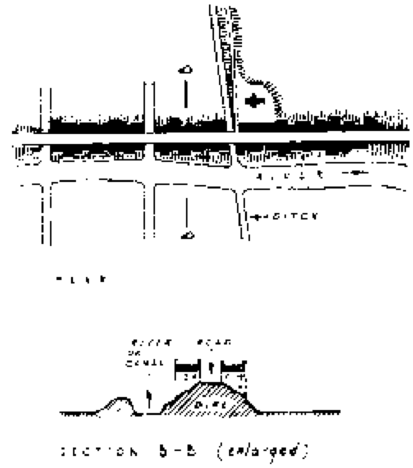
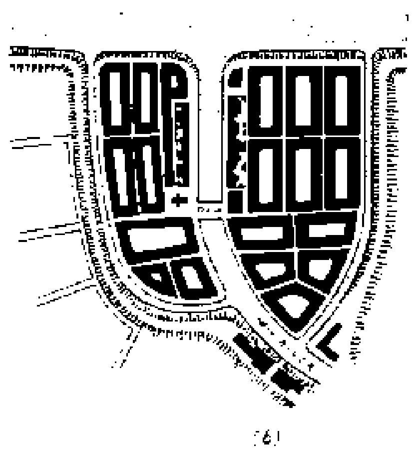
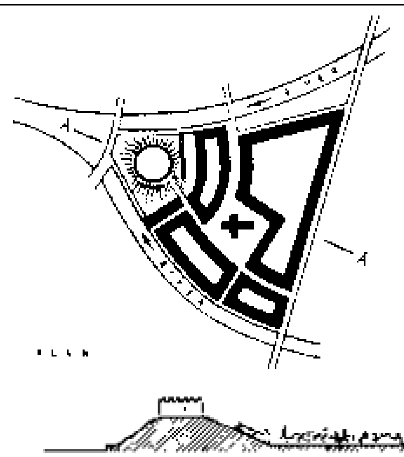
[61] De Vet 1994, 20
[62] Raadschelder and Toonen 1993, 1
[63] Van der Ham 2002
[64] Gettmer 1974, 20-26
[65] Lintsen, 26

Table 2.2 Towns in the Phase of Defensive attitude towards nature

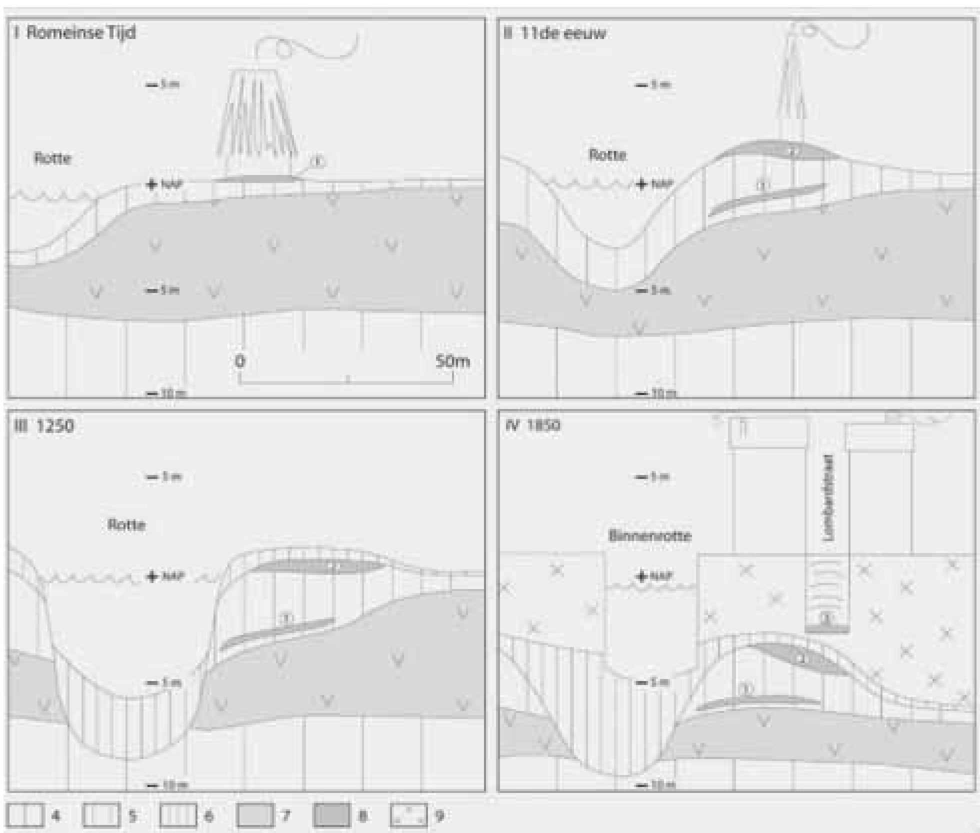
Dike -Close to the water, the water is not necessarily part of the urban tissue -Buildings are oriented towards the water and/or road structures and are parallel to the longitudinal structure of the dike -Larger buildings, such as churches, are placed next to the dike, on mounds Source: Burke 1956	
Dam (Amsterdam) -Close to the water, the water becomes a part of the urban tissue -Buildings are oriented towards the water and road structures -The material from the newly-dug canals is used to raise the building sites Source: Burke 1956	
Burcht (Leiden) -Close to the water, the water is not part of the urban tissue -Buildings are oriented towards water and road structures Source: Burke 1956	

The paradigm of adaptation in natural, accepting and Defensive attitude towards nature defines the way of living with the forces of nature and is able to offer quality and beauty, which perhaps are lost in trusting technology in the next centuries. It is characterized by a mental and physical attitude of flexibility and acceptance of the circumstances of the territory and produces high and dry settlements.

The Dam and the Rotte

Picture 2.2 Rotte and dam in 1340 showing the start of the settlements' main structure
Source: Municipal Archive Rotterdam

Conceptually, the most interesting type of water city is the dam city, like Rotterdam, because of its integration of technological intervention with economical and social structures. The first mention of the settlement 'Rotta' is in 1028, but there are people living on the banks of the peat river Rotte where it flows into the Maas centuries before that. In the second half of the eleventh century the first dike ring is built, but it does not offer enough protection and the settlement of Rotta is lost. In an article about the Rotte and its first settlement, Guiran studies the soil build-up and proves that in the first half of the twelfth century, people had already started to use piles and mats of woven ash wood to prepare sites for building (see picture 2.3).[66] Around 1270 a further, probably the third, dike ring is built (the Schielands Hogezeedijk), and a dam is constructed where it crosses the Rotte.[67] Dam cities are established in the most rewarding places, where smaller rivers flow into a larger river. The dike at these points is the most important requirement for the creation of towns in the polders, because soil compaction and subsidence make these areas vulnerable to flooding. The dam has a water defence function, but with a drainage sluice it also takes care of discharging river water from the smaller river onto open water. A combination of the scouring effect of the sluice water and the tidal movement is cleverly used to maintain the correct harbour depth and keep the town accessible to seagoing ships.



Picture 2.3 Four moments in the development of the settlement of Rotterdam: I Roman Time, II eleventh century, III 1250 and IV 1950; showing the build up of the soil layers. 1 = Roman Time, 2 = house mound in the eleventh century, 3 = oldest pavement in the Lombartstraat, 4 = clay, sediment of Calais, 5 = clay, sediments of Dunkirk III, 7 = peat, 8 = dwelling level 1-3, 9 = fillings after 1340.
Source: Guiran 2004

The economic importance of water transport between sea and hinterland is embodied in the dam with its drainage sluice; these become the heart of the city. The drainage sluice is able to accommodate only relatively small ships, and the cargo from larger ships has to be transferred or traded on the dam.

[66] Guiran 2004, 91-97
[67] Van der Schoor 1999, 21

The dam becomes a market, and the peat river estuary outside the dike a sheltered harbour. The dam town and the polder are therefore bound closely together, not only hydrologically, but also economically and socially. In Rotterdam this is expressed spatially by building important social venues such as the city hall and the house of the Count of Holland on the Middeldam.[68]

From the mid-thirteenth century a dike stretches out along the Hoogstraat (high street), with a dam in the Rotte providing the settlement with the name Rotterdam. The dam is built in 1270 and the sluices enable the people of the settlement – who mostly live on the dikes – and the people in the polder to control the water from the hinterland and protect themselves from the Maas River. The Rotte becomes a *boezem* (outlet water way) and plays a crucial role in the water system of the area. By the tenth century, the polder boards (*ambachten*) have already started to reclaim the peat by digging ditches parallel to each other. The Rotte and the dam come under the control of the Water Board of Schieland, which is established in the thirteenth century.[69]

Before the advent of the windmill the polder boards can only use direct discharge into the river to keep the water in the polders at the most convenient level for growing crops. This has a great influence on the way the city develops, because the discharge rivers flowing through the settlement all have the same orientation, north-south, steering the development. The roads are also laid out in the same direction, perpendicular to the river Maas.

The first layout of the inner city is therefore determined by the water system that forms the main axes along which the roads and houses are built. In the Middle Ages, only the main road of a city is of importance, side roads are of no interest, leaving Rotterdam with insignificant west-east connections (which needed to be corrected in the twentieth century).[70]

The city rights gained in 1340 are immediately used in the physical transformation of the city by digging the Rotterdam Schie Canal and the city moats. The Rotterdam Schie not only alters the future of the city, it also makes a great change in the water system. The Rotte and the Rotterdam Schie ensure excellent connections to the hinterland, enabling Rotterdam to become an important market centre for agriculture. The original dike that separates the water from the Water Board of Delftland (in charge of *boezem* river Schie) from the Water Board of Schieland (in charge of *boezem* river Rotte) is bisected and the two systems merge.

Before digging the Rotterdam Schie Canal, the level of the river Schie is lower than the Rotte and therefore the most convenient route for water discharge. There are no mills so the *boezem* had to discharge the water into the river, which then carries it to sea, making the practicality of discharge completely dependent on the water level at low tide. It is in the interests of Rotterdam and the Water Board of Schieland to discharge as much Rotte water possible at low tide. This causes technical and political conflicts of interest with the Water Board of Delft, which are later partly resolved with

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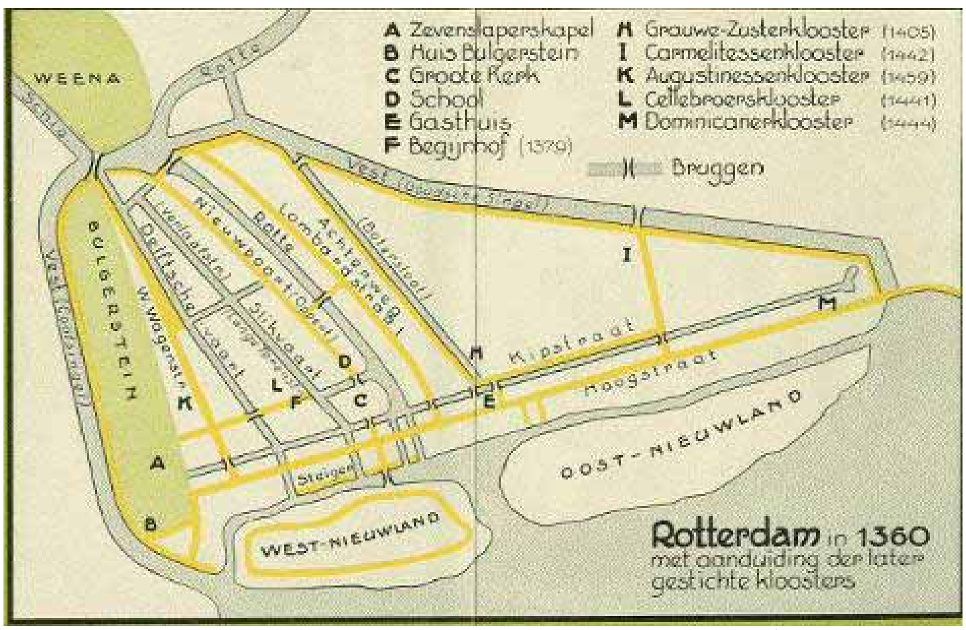
[68] Van der Schoor 1999, 21
[69] Peilbesluit Rotte Toelichting06-09-05, Vastgesteld door VV op 28 september 2005, Goedgekeurd door GS op, Versie 3 (gelijk aan 14 december 2004), Rotterdam, 23 augustus 2005, kenmerk 2004.10528
[70] Van Ravesteyn 1928, 114

the advent of the windmill, enabling Water Boards to discharge water at high tide as well. In addition, by raising the dikes more water can be kept in the *boezems*.[71]

The protecting moats, Coolvest to the west and Goudsevest to the east, give the settlement its characteristic triangular shape. The Goudsevest forms an arc between Weena and Oostplein to include as much land as possible. The same principle is used for the Coolvest, but as it potentially encroaches on the border of another *ambacht*, it spans a smaller section from Weena to the river dike. In the second part of the fifteenth century a wall is constructed on the inner side of these moats, replacing a wooden fence.[72]

Within the triangle, perpendicular to the Rotte, other canals are dug: Delftsevaart, Oppert and Botersloot, with sluices under the Hoogstraat that connect to Blaak, the outside harbour (see picture 2.4). Streets and houses have to be raised frequently due to the soft peaty soil. The configuration of the city, with its waterways and roads, has survived, but the wooden houses have been replaced several times over, leaving no trace of this old city and its many generations of houses.[73]



Picture 2.4 Rotterdam in 1360, showing how water structures the layout of the settlement. The two new city moats (*vesten*) form the characteristic triangular city shape. The channel and *boezem* Schie is at the northern tip of the city.
Source: Municipal Archive Rotterdam

[71] Franx 1945, 92- 99
[72] Van Ravesteyn 1928, 134
[73] Van Ravesteyn 1928,144

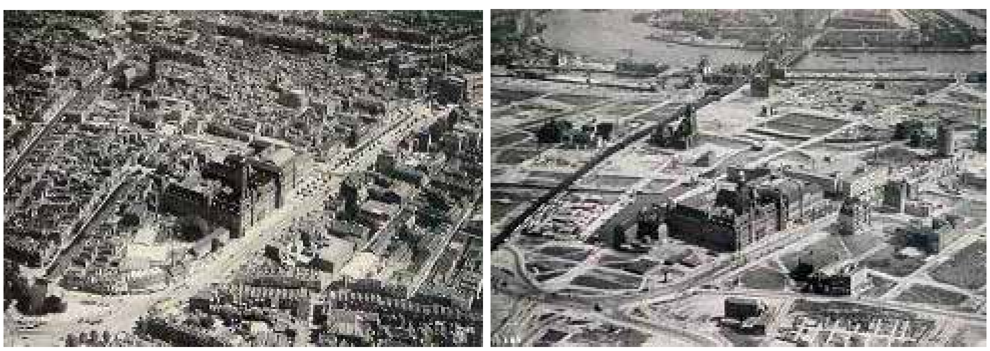
Loss of the Inner City

Rotterdam is a typical Dutch water city with a characteristic city triangle and with the north-south oriented waterways and street layout as the main composition of the city (together with the *Waterstad*, which is built in the seventeenth century and is the object of study in chapter three).

Until the first (real) expansion with the *Waterproject* in the 1860s (the object of study in chapter four), the urban tissue becomes very dense because every free piece of land is built upon. After the realization of the *Waterproject* more attention is paid to the spatial upgrading of this very crowded city centre.

One big issue is traffic, and different waterways are filled in, Goudsevest between 1897 and 1904, Schiedamsevest in 1885, Coolvest around 1920 and in 1877 the Rotte, once the lifeline of Rotterdam, is filled in to enable the railway to be constructed right through the heart of the city. Also in the traffic scheme the north-south orientation is adjusted with some new east-west connections such as the Meent, which is created in the 1920s. These filling-ins and breaks through existing blocks slowly change the original urban tissue of the city.[74]

The greatest change to the city triangle is its bombing on 14 May 1940. This is the start of the Second World War in the Netherlands, and the heart of the city and 800 lives are lost.



Picture 2.5 Rotterdam before and after the bombing. The old city moat Coolvest is filled (1910s). The new Route of the Rotte is built.
Source: Municipal Archive Rotterdam

The focal point in the reconstruction of the city centre is to swiftly reinstate city services, offices, shops, housing and docks. In the rebuilding plans water is given an altogether different, more marginal, role than it had had prior to 1940, both aesthetically and infrastructurally. The first reconstruction plan is presented a mere month after the bombing and comes from the drawing board of the Director of Public Works, W.G. Witteveen. In Witteveen's plan water very specifically means connections, yet many of the waterways and canals defining the inner city before the war are not included. The only water-based link in the inner city to which Witteveen attributed a great future is that between the river Rotte and Leuvehaven in the *Waterstad*,

[74] See for the rail history in Rotterdam: Borselen1993

which before the war had been a narrow winding route.[75]

Although by 1945 the Rotte route is completed, reconstruction of inner-city buildings has still largely to begin. A new plan, the 'Basic Plan' by Witteveen's assistant C. van Traa, is drawn up in 1946.Van Traa regards the water that Witteveen introduced as an element of beauty, in his opinion the Rotte route is oppressive and un-metropolitan. Van Traa has great difficulty fitting the system into his city plan. By placing the development with its rear side to the quays, the city's back is literally turned on the water. [76]

Picture 2.6 *Basisplan* (Basic Plan) for the rebuilding of the Inner City by Van Traa
Source: Municipality Archive Rotterdam

In the 1970s plans are made to make the water more useful and interactive, such as a plan to transform the Delftschevaart into a recreational area called *Waterverband*, which is not realized. The city is desperately in search of its identity and water might play a role in that. The technocracy of the post-war[77] period meets a lot of resistance in the 1970s when it is felt that the city should be more *gezellig* (cosy and enjoyable). Along a large part of the Delftschevaart a housing project designed by Jan Hoogstad is built that is predicated on the fact that water is seen as part of the Dutch identity.[78]

For all the monumental design with brickwork quays and arched bridges, today the Rotte route is scarcely recognizable as a prime urban space. It is somewhat tucked away, though in places it still affords an unexpected view of the silhouette of the inner city. No alterations to the

[75] Schadee 2000, 444
[76] Schadee 2000, 242
[77] In Dutch this era is called *Wederopbouw* aiming at the euphoric rebuilding of a destructed country with the use igh technology and in the spirit of modernism.
[78] Schadee 2000, 243

system have been made since the 1950s and slowly the post-war city centre is being transformed into a twenty-first-century city. And now, in the new plans for the Laurens Quarter, the buildings face the water rather than turning their backs on it. The details of Witteveen's plans and organization of the water fit the current urban ideas for revitalization of the post-war city centre.

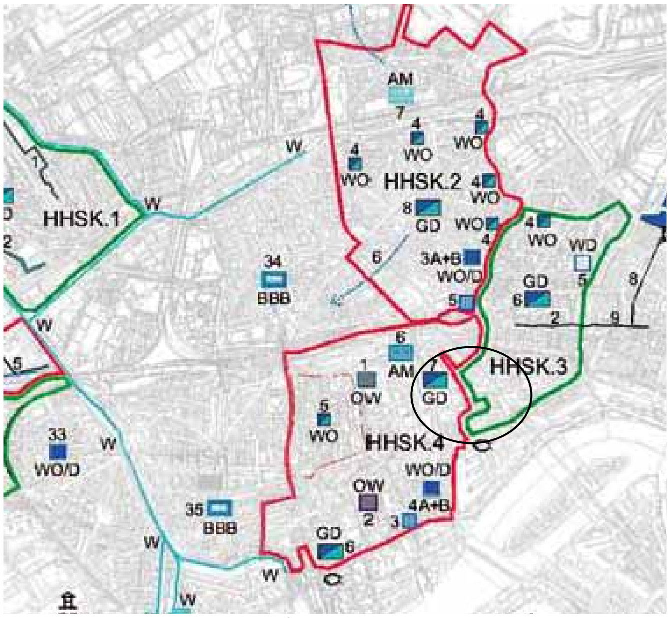
Rotterdam Dam City in 2011

The historical city centre of Rotterdam is now 60 years old. The variety of urban types and in quality is quite large for the small area; however, the discussion and the plans for the future are major. A huge transformation is taking place, in programme and in scale. The water structure of Delftsevaart connected to the Rotte is the only water left; the original dam of Rotterdam was lost when the Rotte was filled in. The original north-south orientation of the main structures in the inner-city has been altered even more rigorously in the post-war reconstruction era. Because larger-scale buildings now dominate the urban design, any connection to the old dam city has become impossible.

The water system has been changed in the same way as the urban pattern. Pumping stations and pipes drain the inner city and a large dike along the river now also protects the *Waterstad*. The function of water in the inner city in the future is described in the *Waterplan* 2; there is presently no plan for its role in parts of the municipal centre.

The *Waterplan* divides the city into different sectors and defines for each sector what role water should play and what measures are necessary to keep the city dry and the water in good quality. The old city triangle is part of two different areas with a specific purpose relating to water: HHSK.3 and HHSK.4. The border between HHSK.3 and HHSK.4 is the Delftsevaart, which continues into the Rotte. HHSK.3 covers the largest part of the inner city and to solve the finer differences in water expectations, a green roof programme and two water squares are mentioned in the plan.

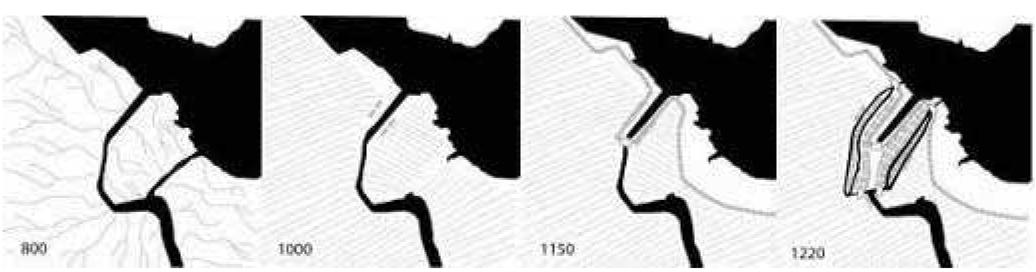
Since the original dam city is significantly altered it is difficult to assess whether this approach is sufficiently robust to deal with the challenges posed. Perhaps if all the waterways are kept in use there will be fewer problems with the discharge of rain during severe storms in the inner city of Rotterdam. For example in Amsterdam, another dam city with comparable characteristics, the canals (used for the storage, drainage and discharge of water) occupy a large percentage of the city's surface, and no problems or inconveniences with water are experienced during rain storms.



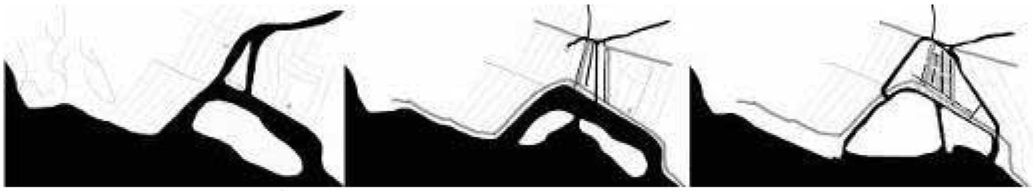
Picture 2.7 Waterplan 2, defined areas with proposed measures. The old inner city falls in the area named HHSK.3 and HHSK.4 (HHSK stands for Hoogheemraadschap van Schieland en de Krimpenerwaard). The two areas are basically still the same units as in the fourteenth century as described above.
Source: Waterplan 2

The Fine Dutch Tradition: Episode One

Rotterdam is an excellent example of the paradigm of adaptation: a town developing closely with the landscape and water system, all assuming a common identity. Without design or plan, a pragmatic response to the circumstances dictates the layout of the town. For water management and building-site preparation this means that a system of canals are dug (for drainage and soil supply) that give the urban pattern its north-south orientation. This shows that the technology used to drain and protect (to dig canals and to build dikes respectively), also defines the urban 'design' of the city: urban principle steps that foresee a closed water-soil balance.



Picture 2.8 Development of Amsterdam during the Natural Phase
Source: Hooimeijer 2005



Picture 2.9 Development of Rotterdam during the Natural Phase: 1000, 1340, 1500
Source: Hooimeijer 2005

The layout of the settlement is not consciously planned and not completely 'chance growth' as Burke describes, but follows the principle steps.[79] It is the logical result of dealing with the difficult physical geographical circumstances when organizing the urban elements needed for social and economic reasons. Burke writes 'the poorest natural resources . . . constant danger' on urbanization that is done with 'qualities of courage and tenacity, ingenuity and faith' demonstrated in the Dutch landscape and cities.[80] The vulnerable situation is put to profit, an important mental aspect of the Fine Dutch Tradition, because water offers possibilities for good trading by being a transport route and provides drinking water (the two main functions of water in the city). It is meaningful in a physical sense since the logic of the physical geography, wherein water (hydrologic) and the soft soil are the distinguishing characteristics, is expressed in the urban form. The dam becomes an urban artefact that represents technical, social and economical circumstances: the first state of the art of the Fine Dutch Tradition. The dam city shows how tight economics, social construction, geography and water management are connected.

In the first two Phases of nature and defence the Fine Dutch Tradition, in the context of urban design, is very closely connected to the landscape delineation through the importance of physical geographical and hydrological circumstances. In the first Phase of the framework the choice of location of settlements is emblematic and, secondly, when the Defensive Phase comes about, in preparing the location to facilitate settlements with the dike.

The adaptation paradigm of the attitude of nature and defence produces high and dry settlements: mound, dune, and river cities, dike, dam, *burcht* and coast and cape cities. During the first Phase of this attitude towards the natural system, settlements are geographically situated in dry places. The dike marks the start of the new Phase of defence and brings a paradigm shift towards the alteration of the geographical circumstances by building a dike or dam, or, on a smaller scale, a *burcht*. The dike also makes it possible to locate settlements on geographically very fruitful, but perhaps not as safe, locations and to integrate a harbour into the urban tissue.

[79] Burke 1956, 33
[80] Burke 1956, 163

Chapter 3: The Power of Unity (1500-1800)

Land of cities and shipping

The technology that marks the transformation to the next Phase of the Anticipative attitude towards the natural system is the windmill, which arrives on the scene on a larger scale around 1500. This Phase is characterized by a new attitude towards the water: people start to develop technologies to better anticipate water conditions and to make them profitable. The first mill mentioned in the Netherlands is built near Alkmaar in 1408,[81] and in 1434 the first is built in the Rotterdam area, where it pumps water from the Spaanse Polder into the Schie.[82] This new mechanism allows larger volumes of water to be moved and offers a more effective method for keeping larger areas and cities dry. The availability of new hydrological instruments (besides mills, sluices and dams are also built) changes the approach towards the natural system from Defensive to Anticipative.

During the Anticipative Phase, the Dutch learn that their hereditary enemy should be fought on its own territory in order to conquer it. The fight results in a quality of social levelling that prevents the feudal system from becoming deeply embedded in the Middle Ages. Dikes are built and maintained by the community to protect the property of its members. Everyone living behind the dike has the same responsibilities, duties and rights towards its upkeep. This leads to a great sense of self-government and concepts of freedom, still recognizable in Dutch society today.[83] The fight is the essence of the social character and keeps the workers' feelings and cultural philosophies in place.[84]

The paradigm that accompanies this Phase of the attitude towards nature is fertility. It is no coincidence that Ed Taverne named his book about city building during this time *In 't land van belofte* (the promised land). The unifying powers are in water management and the organization of society. The last is formalized in the signing of the Treaty of Munster with Spain in 1648, recognizing the Republic as an independent state. This makes it possible to make the best of all the potentials of society: ships bring in valuables from afar and land is made out of water. This is reflected in the many colonial cities all over the world:[85] Offensive diking, reclamations, large-scale land exploitation, the improvement of the national infrastructure by an extensive network of canals (1632-1667) and the expansions of cities.

The Netherlands in the seventeenth and eighteenth centuries is attractive because of its landscape, towns, parks and buildings, and because everything in the country seems to be vital and alive. This alert and assertive attitude is linked to the continuous fight against the water that produces a

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[81] Lendering 2005, 43
[82] Van der Ham 2004, 71
[83] See for the current conditions of the phenomena Lendering 2005
[84] *De Ingenieur* (1930) 47 e.v.
[85] See the publication by Van Oers 2000

magical landscape wherein the drainage systems form exact plots with regular geometric forms and cities are hydrological machines. The Dutch are proud of their resurrected and renewed country and its praises are sung by visiting foreign merchants and travellers. The achievements of the Dutch are also lauded in a myriad of books, pictures, etchings and maps published in the Netherlands and exported all over Europe.[86]

As is characteristic of modern civil society, the future is consciously planned on the basis of rationality, mutual consultation and decision-making,[87] relating to making the best use of the fertility of the territory. In the Republic this is accompanied by the fertility of flourishing science, technology and art: the Dutch Renaissance. This is, of course, very strongly connected to the Age of Enlightenment, the era in Western philosophy and intellectual, scientific and cultural life centred upon the eighteenth century, in which reason is advocated as the primary source and legitimacy of authority.

The developments in this Phase are founded on the developments that take place in the fourteenth and fifteenth centuries in Italy. There, a group of engineer-artists appears, of which the best known is Leonardo da Vinci (1452-1519). The group is characterized by creativity, sharp observations and ingenious sketches in the fields of architecture, mechanical engineering, and civil and military technology. Besides siege strategies and weapons they also design fortifications, palaces, cathedrals, roads, channels and instruments. In their work technology is strongly connected to aesthetics and art. They have a humanist way of life: placing man in the centre and using him as the measure of all things.[88] These Italian designs inspire Dutch military engineers like Simon Stevin.

The recognition of the 'Republic of Seven United Provinces' in 1579 is followed by the installation of an organized army that amasses knowledge by building fortifications, canals and bridges, surveying, etcetera. Thus the Dutch become experienced in dealing with building on the wet and weak grounds of their territory. They become especially proficient in building cities and fortifications. Despite the existence of a geographical unity, there is no strategy for central defence; it is still a land of cities where each is responsible for themselves. The divide between different cities and between city and countryside is wide, and the concentration of power, wealth and knowledge is in the cities. The union is a land of cities wherein the cities compete each other and dfend their own.

From the thirteenth century, town privileges are granted to the basic types of water towns like *geestgrond*, mound, river, coastal, *burcht*, dike and dam towns, on a large scale. The privileges include the right to hold a market, which is an important economic stimulus for the development of a settlement into a town. Because of the lack of any strong central Authority, towns have to defend themselves, usually by erecting a wall. The economic system of town and surrounding areas, with the respective functions of market and production landscapes, means it is in the town's best interests to keep the surrounding areas dry. In the same way that individual towns

[86] Gorbatenko 2003, 265-266
[87] De Vries 1997, 35.
[88] Lintsen 1985, 11-15

arrange their defences, certain parts of the production landscape are ringed by dikes to protect against overflowing rivers.[89]

The seventeenth century is a Golden Age for the Republic, largely because of the thriving overseas trade. Cities grow and more possessions have to be protected from the water: 30 per cent of the population lives in cities, wooden cities are transformed into stone (this picture was high in comparison to surrounding countries, where only 10 per cent lived in cities). Small cooperatives are founded because most people have small businesses and in this way everyone shares in the prosperity.[90]

The economic growth causes towns to flourish. Prosperity and growth of the cities leads to expansion onto the surrounding wet soil, derived from peat or already prepared for cultivation, but not yet prepared to be built upon. This Phase is the era of the peat polder city, the start of intensive building-site preparation to make land out of water and build cities in poor physical circumstances. The design of the cities is done in the City Factory (*stadsfabriek*) by the craftsmen, carpenters; there is no education in architecture or urban design.[91]

This chapter is about the Early Modern Period that thrives on the high productiveness of the territory and those occupying it. The cities are closed in the sense that they concentrate people, wealth and knowledge as islands in a countryside that is relatively 'wild'. With reason and logic cities are developed for practical purposes; all that is possible is made. This era of fertility is enabled by the unity of the powers that are discussed in this chapter. The end of the era starts in the eighteenth century which, in contrast with the Golden Century, is a century of decay and war. The Dutch lose their position of economic and political pre-eminence, the accumulation of wealth and knowledge come to an abrupt end and the development of cities in the peat polders is postponed to better times, or maybe until new technological advances are made.

The icon of Dutch urban design in the Golden Century is of course the *Grachtengordel*, which plays an important part in this chapter. For Rotterdam the case is *Waterstad*, not a polder but a river expansion that closely shows the relation between technological possibilities versus urban development (and money).

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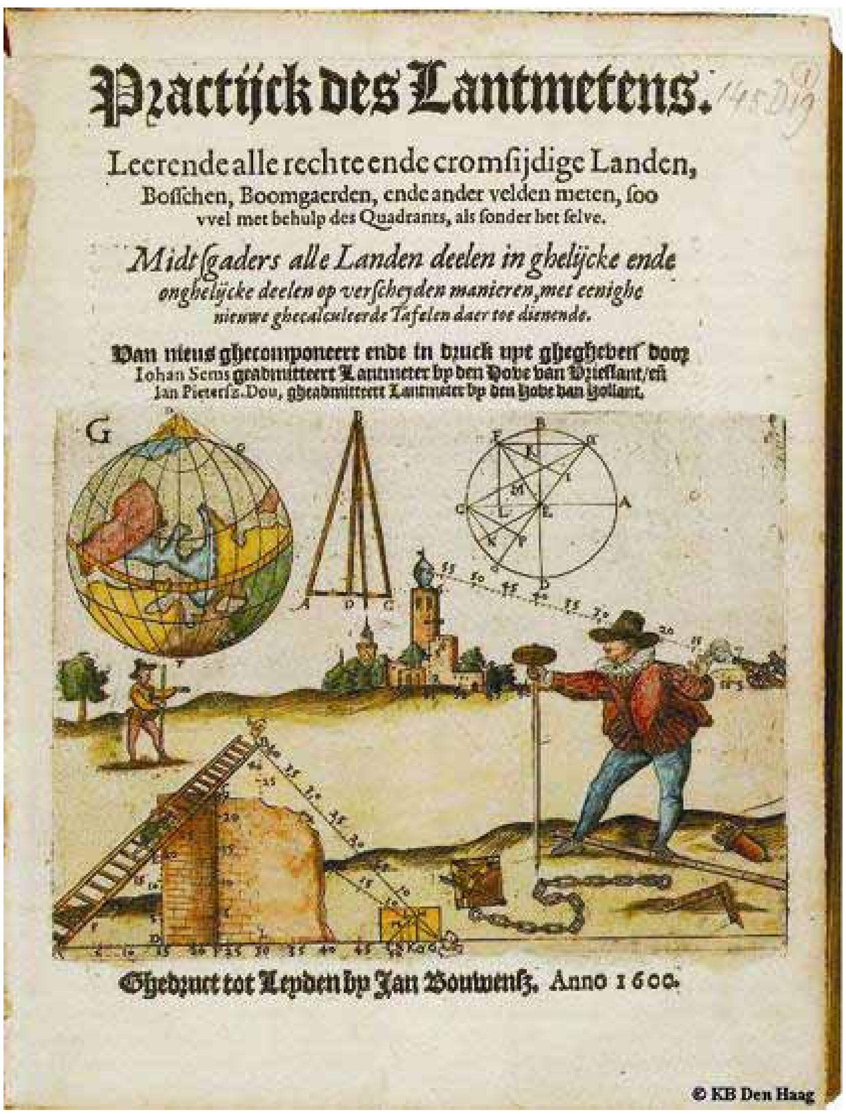
[89] See chapter six: Stedelijke invloed op de zeventiende eeuwse Droogmakerijen, in: Raadschelders and Toonen 1993, 81-91
[90] Hoogenberk 1980, 5
[91] Van der Wal 1974, 20-26

Urban Engineering

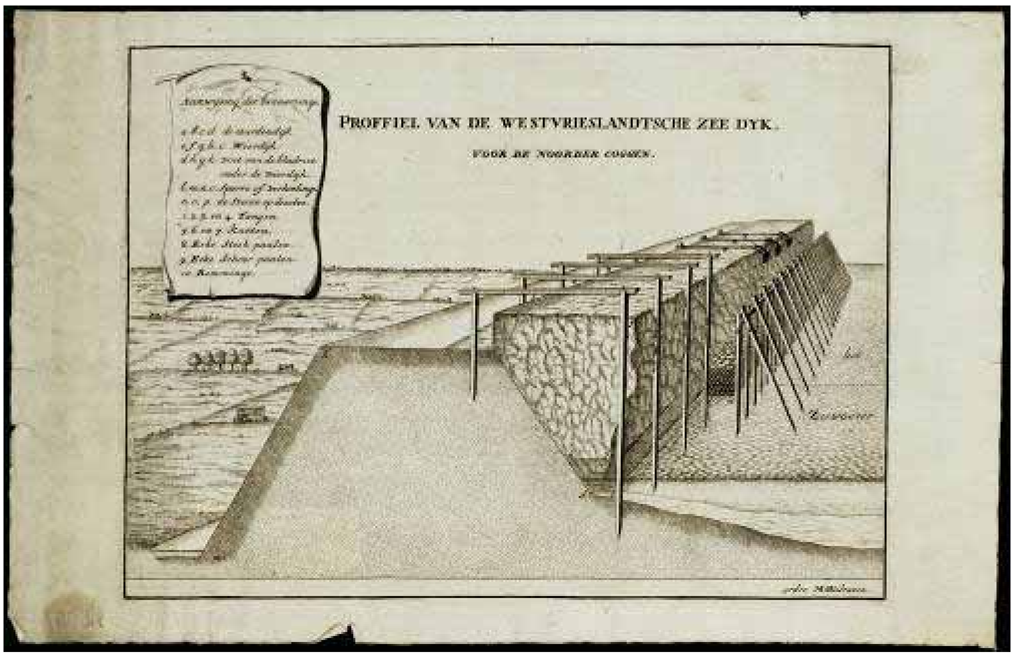
Since the fourteenth century surveyors have been specialists in separating private from public, securing property issues.[92] At the new University of Leiden, established in 1575, professor B. de Volder educates students to become surveyors. Surveyors are no longer military, but civil engineers who play an important role in collecting the taxes required from property owners since the founding of the 'Republic of Seven United Provinces' (1579). In 1645 it becomes mandatory to pass formal examinations in mathematics, geometry, goniometry and trigonometry to become a surveyor.[93]



Picture 3.1 Practice of cartography by J. Sems en J.P. Dou (1600)
Source: Koninklijke Bibilotheek Den Haag

[92] Lintsen 1985, 26
[93] Lintsen 1994, 23-27

In the fifteenth century the distribution of the first scientific publications become possible through the invention of the art of printing. Within the discipline of surveying more publications about cartography are brought onto the market. Thanks to triangulation (1533), devised by Reiner Gemma Frisius (1508-1555), maps are more accurate and the cartographer Jacob van Deventer is one of the first to work with this. Jan Pieterszoon Dou (1573-1635) designs the Dutch Circle, an instrument that he uses in 1608 when taking measurements for the diking of the Beemster. With the Dutch Circle, perpendicular lines can be set out, compass directions determined and angles measured horizontally as well as vertically. The Dutch Circle remains in use for two centuries. Snellius (1580-1626) invents instruments with which the distance between two mutually distant points can be accurately determined.[94]



Picture 3.2 Profile of a sea dike
Source: Regionaal Archief Alkmaar

Surveying becomes a professional occupation, as surveyors are the source of the knowledge required to control the land use and of the many books published on the topic. Surveyors in training have to study the book *Practijck des Lantmerens* (the practice of cartography) by J. Sems en J.P. Dou (1600) see picture 3.1. In 1662 the surveyors M. van Nispen and M. Hoek write *The Abridged Art of Cartography*, a book that is much used until the eighteenth century. In 1707, J. Morgenster publishes *De werkdadige meetkonst* (Practical geometry), a guide for surveyors that remains in use until the nineteenth century. In 1798 engineer C.R.T. Krayenhoff begins building a topographical map of the complete territory of the Netherlands, accurately drawn on the basis of a triangulation network. In the eighteenth

[94] See for the Dutch mathematicians: Haasbroek 1968 and De Wreede 2007

century the profession of surveyor is often combined with that of bricklayer, carpenter, teacher, notary and cleric.[95]

In the seventeenth century architects assume the role of master builders, although they are not trained as such but are usually painters. In the eighteenth century the tasks are divided, with architects undertaking only aesthetics and master builders (former bricklayers) executing the technical side of the buildings. This breaks the typical connection between aesthetics and technology (respectively architectural design and craft) that was evident for many centuries and is the start of the segregation that is completed at the beginning of the twentieth century.[96]

The Military Engineer

First there is craftsmanship, hydrological knowledge based on experience. The engineers make this knowledge scientific by incorporating natural scientific and mathematical concepts, laws and theories. The first engineers in the army work on fortifications, canals, military equipment and bridges. Not until the end of the eighteenth century are mathematics and natural science included in their education.[97] The Latin word for engineer is *Ingenium*, which means ingenuity or acuteness, but during the Middle Ages it also means instrument of war.[98]

The first civil educational course for engineers is initiated by Prince Maurits in 1600: *Duytsche Mathematique*, instruction for architects of fortresses, dikes and hydrology (studying the properties, distribution, and effects of water on the earth's surface, in the soil and subsurface, and in the atmosphere), and so professionals were trained.[99]

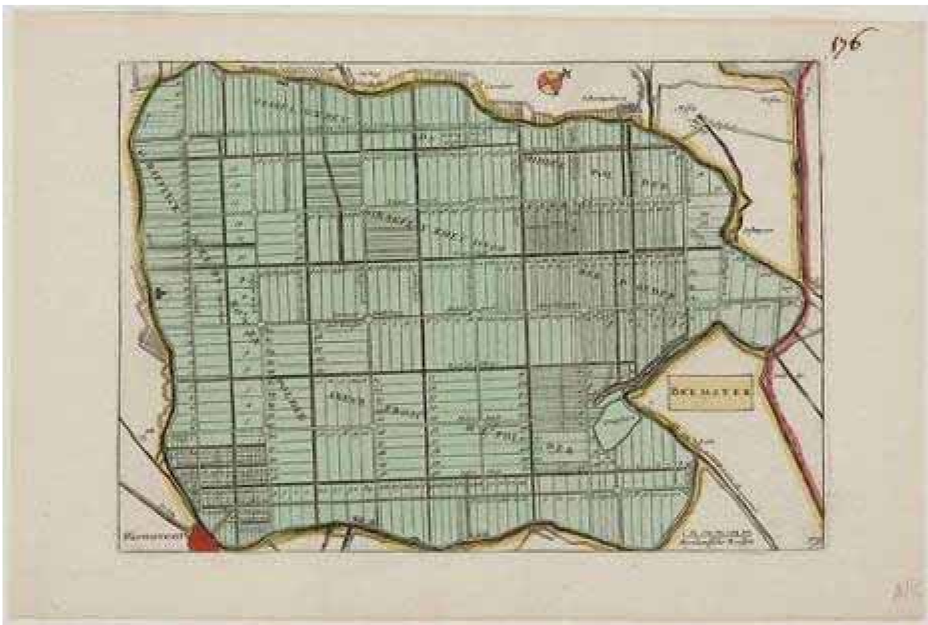
The scientific revolution in sixteenth- and seventeenth-century Western Europe is characterized by the increasing independence of natural scientific research from theology and philosophy. The experimental system is used to formulate hypotheses and theories, reflect on these, and to give guidance to new knowledge.[100] The great difference from the Middle Ages is that engineers begin to use mathematical language. This mathematical language is evident in Simon Stevin's Ideal City, as will be described later in this chapter; and it is also the language of surveyors. This mathematical language describes the dimensions of the water system that can be connected to the scale of the new urban plans that are created. The water system, building site preparation and urban development all become of one scale and one language.

Important military engineers in this Phase are Jan Adriaansz Leeghwater (1575-1650), who is responsible for the drainage of 27 lakes and the peat lake the Beemster in North Holland (1608-1612); Andries Vierlingh (1507-1580), a dike building specialist who publishes *Tractaet van dijckagie* (A Treatise on Dike Management) (1577) on the construction and management of dikes and sluices; and Simon Stevin (1548-1620), who presents his tidal theory and theories on the creation of sandbanks, meandering rivers and

[95] Lintsen 1985, 27; Fockema Andreae and Van 't Hoff 1947, 10-23
[96] Van der Wal 1974, 34
[97] Lintsen 1985, 15
[98] Lintsen 1985, 17
[99] Lintsen 1980, 27
[100] Lintsen 1985, 24; and Musson and Robinson 1969,12

erosion by water, with which waterways are created. He publishes *Nieuwe maniere van sterctebou, door spilsluysen* (New ways of hydraulic building with sluices) (1617).

In this century more than 200,000 hectares are drained by the impoldering of Wogmeer (1608), Wieringerwaard (1610), Beemster (1612), Purmer (1622), Wormer (1626), Heerhugowaard (1631) and Schermer (1635). In 1607 Amsterdam merchants started the project of the Beemster of 7.100 ha. Many mills were necessary to keep it dry. The landscape design is inspired by the Italian Architecture trend of geometrics of that time.



Picture 3.3 A drained lake - the Beemster is pumped dry in 1612.
Source: Regionaal Archief Alkmaar

Also in this period the first scientific writings appear about soil mechanics by Charles-Augustin Coulomb (1736-1806) who publishes an important treatise on the failure of soils in 1776, Bernard Forest de Bélidor (1697-1761) who writes about three fields of knowledge considering building-site preparation, Daniel Bernoulli (1700-1782) important for hydrodynamics and the first major guide about sluices, *The atrum Machinarum Universale* is written by Tileman van der Horst (1736). At the end of the eighteenth century the military engineers are educated in mathematics and physics. The scientific approach based on mathematics, laws of physics and theories becomes dominant within the engineering discipline, which developed out of craftsmen who gained knowledge through experience.[101]

Before the work of Swiss scientist Daniel Bernoulli (1700-1782), there was no scientific knowledge about the behaviour of fluids. Bernoulli's law describes the behaviour of a fluid under varying conditions of flow and height, so for the development of water management, and hydrodynamics his work is very important.

The development of hydraulic engineering in France is closely linked to

[101] Lintsen 1980, 1

the foundation of the *Corps des Ponts et Chaussées* (Bridge and Highway Corps) in France in 1716 with the establishment of the *École Nationale des Ponts et Chaussées* (National School of Bridges and Highways) in 1747. There, professor Bernard Forest de Bélidor (1697-1761) writes the hydraulic standard work *Architecture Hydraulique* and the engineer's bible *La Science des ingenieurs, dans la conduite des travaux de fortification et d'architecture civil* (1728), which also considers building on deficient soils.

In De Bélidors work the close relation between water management and soil conditions is obvious. According to his book, information on the state of the soil should first be obtained from the locals and a boring test should be conducted to get an idea about the strength and load-bearing capacity of the site. The use of piles should be avoided, but if really necessary then they should be driven in as deeply as possible. On peat De Bélidor advises a foundation that is as shallow as possible.[102] Here, next to water and soil, also one of the other aspects of building-site preparation that will become a independent field of knowledge is mentioned: pile foundations.

The transition from wooden to stone houses in the sixteenth century means that most houses now need a foundation due to the pressure put on the weak soil by their weight. Long wooden foundation piles are driven into the prepared ground to provide a stable foundation for the housing on the deep-set stratum of sand. By the use of a mechanism the piles are rammed into the ground by dropping a heavy, wooden block on the pile. The block work is originally done by four men, by hand![103]

In the seventeenth century foundations on piles become more common. Piles with one sharpened end are driven into the ground until they hit a sand layer. The heavier the building, the longer the piles have to be in order to reach stable ground. In Amsterdam the usual depth is 7 m, while piles are driven to the second layer of sand, 11 m below Amsterdam Mean Sea Level (*N.A.P.*)[104], for heavy buildings. Amsterdam's city hall (the current Royal Palace at the Dam) is built in 1648 on 13,659 piles. When some of the piles are removed in 1938, they were still in perfect condition![105]

In 1776 Jacob van de Werken designs a new machine that drills foundation piles into the ground. This machine makes use of horsepower instead of manpower to drive the piles into the ground. It is an improved version of a machine designed by the French watchmaker and professor at Oxford Vauloué (1683-1774), who had written several books on physical and mechanical subjects.[106]

In the eighteenth century there is a wide interest in science, including thoughts about conquering nature and the development of knowledge that is applicable in social situations.[107] This interest is reflected in the founding of many societies in the second half of the eighteenth century. Fortification builders were united in the corps of Dutch Military Engineers as early as 1695.[108]

The professionals in this Phase establish a body of knowledge in the

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[102] Verbong and Cuperus 1994, 160
[103] De Vet 1994, 21-22
[104] In Dutch: *Nieuw Amsterdams Peil*
[105] De Vet 1994, 20
[106] Pieck 1982, 260
[107] Lintsen 1985, 25; Ben-David 1971, 77-87
[108] Lintsen 1985, 30; Kuijpers 1871

military world based on their experience. Primarily mechanical and mathematical knowledge is extended, leading to the development of machines and tools to improve building on wet and soft soils. It is obvious that the Age of Enlightenment, when scientific life and reason are advocated as the primary sources and legitimacy for Authority, stimulates scientific development and organization enormously.

The Making of Dutch Towns

'Dry Core'

The peat polder city, the oldest polder city, has its base on the river, coast, *burcht*, *geestgrond*, dike, and dam towns. This base is the first important characteristic of the peat polder city: the higher-level 'dry core' on which the settlement started. Prosperity and growth lead to expansion onto the surrounding wet soil, derived from peat or already prepared for cultivation by draining ditches, but not yet prepared to be built upon.[109] A peat polder city is basically an expansion. This is what illustrates the first difference between the peat polder city and the polder cities developed later, built in a drained lake or within a diking of the sea: they have no 'dry core'. Examples of these 'new towns' (lacking a dry core) from the sixteenth century are Willemstad and Klundert, built as strategic fortifications in a sea polder.

Strict Control

Of the various dry cores on which the peat polder cities are developed, the dam town is the most meaningful. One could say that dike residents who live alongside a peat bog and control the water by building a dam are conceptually ahead of the peat polder cities. This is where the second important spatial characteristic can be seen: the need for 'strict control' as the result of the caution with which an expansion of the polder city needs to be realized.

First, the size of the expansion has to be determined, which not only needs to comply with the requirements of that time, but for centuries to come as well. The second aspect is a technical plan in order to ensure that water can be discharged and controlled, and that the water in city canals will stay at a constant level. In most cases the start is initiated by building an encircling canal (outer canal), which is connected through the expansion area by means of a sequence of parallel canals. The outer canal is primarily built for drainage, but also has a military or Defensive function and a transport function (access to warehouses).[110] The oldest peat polder cities discharge the water from the canals into the rivers without pumping, creating the outlet water level known as *boezem* in Dutch. Draining peat polders causes them to subside, however, creating polder expansions situated lower than the surrounding area. The 'natural' discharge of water is impossible under such circumstances, necessitating the use of sluices and windmills to regulate the water level. This is called the polder water level.

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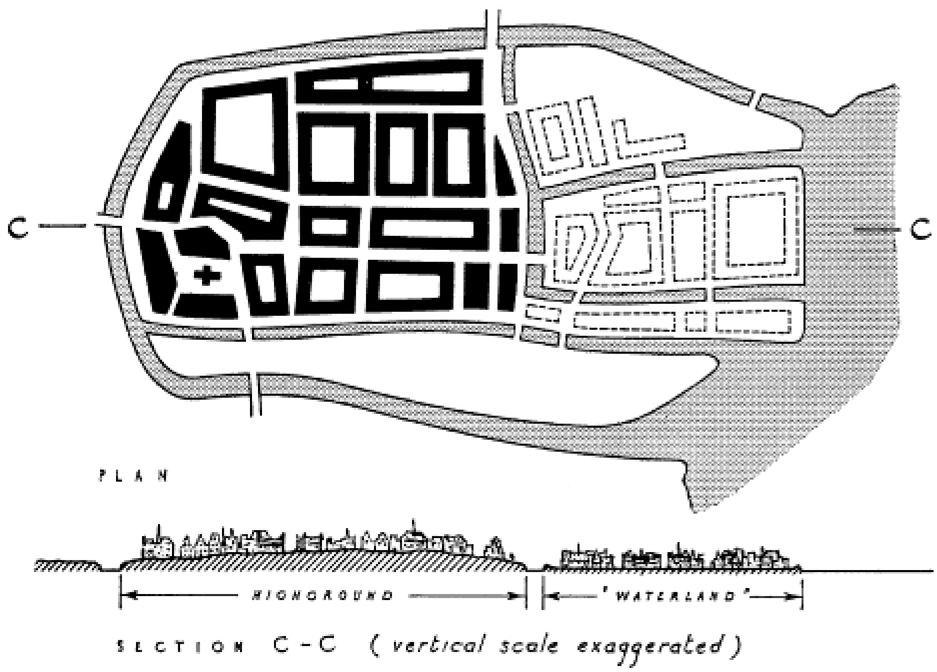
[109] Burke 1956, 33 ff.
[110] Burke 1956, 64 ff.

When swampland is reclaimed it must to be filled in order to obtain the required protection level, and it has to be consolidated and prepared for building. Mud excavated from the canals is used to fill the level (a technique known as *aanmodderen* in Dutch)[111], supplemented by soil that often has to be brought in from far away. Long foundation piles are driven into the prepared ground in order to stabilize the housing on the deep-set stratum of sand.



Picture 3.4 Alkmaar in the sixteenth century
Source: Burke 1956

The difference between the urban composition of the 'dry core' and that of the polder city can be seen on the map of the early medieval Alkmaar and its sixteenth-century expansion in the peat (see picture 3.4). The informality of the higher-level section, located on *geestgrond*, stands in contrast to the strict control employed within the polder city. The difference in level of the urban ground is also unmistakable: from the 'dry core' the streets indicate a slightly descending course, while the water level in the canals remains the same.

It is obvious that random development is absolutely not an option in an area when so much effort needs to be put in reclaiming, raising, draining and protecting it. 'Growth by chance' is out of the question in polder cities due to the cost and effort of building on the reclaimed land: this land has to be used optimally.

This requirement is met by means of a detailed plan with an orderly, compact layout, in which no room is reserved for markets or wide streets. The quays along the canals are the only public areas, so rows of trees are planted on each side of the canal in order to beautify the city. The canals

[111] This term in our time has a negative connotation when it is used for enterprises that do not seem to be successful in an efficient way. This maybe shows how labor intensive this way of building cities is.

function as promenades in the summer and skating rinks in the winter. The rows of trees are an aspect borrowed from the polder landscape where trees are planted on either side of polder roads and encircle farms to serve as fencing and windshields.[112]

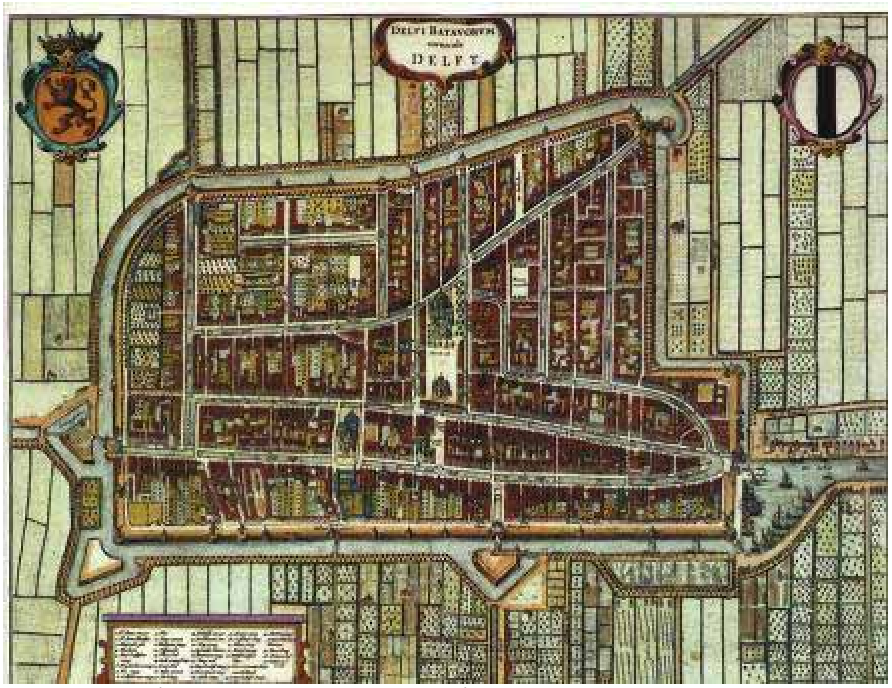
City Water versus Polder Water

Delft, one of the oldest polder cities, abandons its dry core around 1400 AD and develops into a typical canal city. The city takes its name from its location on an *boezem*, later turned into a canal: the word *Delf* is derived from the word *delven*, which means 'to dig'. The old *boezem*, the Oude Delft, is presumably dug around 1100 AD in order to drain the peat bogs of the Leede and the Schie. On the raised location where this Delf intersects the creek wall of the silted up river De Gantel, urban development starts with the establishment of the count's manor. The market is raised in 1484 by 90 cm and after the city fire of 1536 all the rubble is used to raise the lower, not yet built up, parts of the inner city.[113]

In the sixteenth century Delft is connected to the boat-canal network, which consists of a fine maze of natural and excavated watercourses. As such, the city has a direct connection to rival cities such as Leiden, Haarlem and Amsterdam. In the sixteenth and seventeenth centuries most city expansions are situated in the lower-level western part of the Netherlands, which is more prosperous due to access to easy transportation. The fact that urban and regional water systems coincide means that the 'machinery of civil engineering works' permeates both systems (urban and regional) simultaneously.[114]

The boat-canal network is strong evidence of the regional coherence within the water system, and therefore of the Netherlands as a 'water machine', and at the same time provides evidence of a major economic involvement. Even though there is no national state or scale to steer this devlopment, individual cities and entrepeneurs do realise these large scale water structures. In his book *The first modern economy*, Jan de Vries argues that the boat-canal network is an example of the modern attitude of the Dutch mentality and development. With the word 'modern' De Vries refers to the fact that development and improvements are based on conscious intervention, as the established path is not 'simply' followed.[115] This phenomenon corresponds with the strict control of the construction of polder cities, and can be considered typically Dutch. The drainage of the Beemster (1608-1612) and the construction of the Amsterdam *Grachtengordel* are, apart from the boat-canal network, two other significant results of private-public enterprice and the 'machinery of civil engineering works'.[116]

[112] Burke 1956, 65
[113] Segeren and Hengeveld 1984, 26
[114] De Wit 2003, 11
[115] De Vries 1997, 35
[116] De Vries 1997, 35

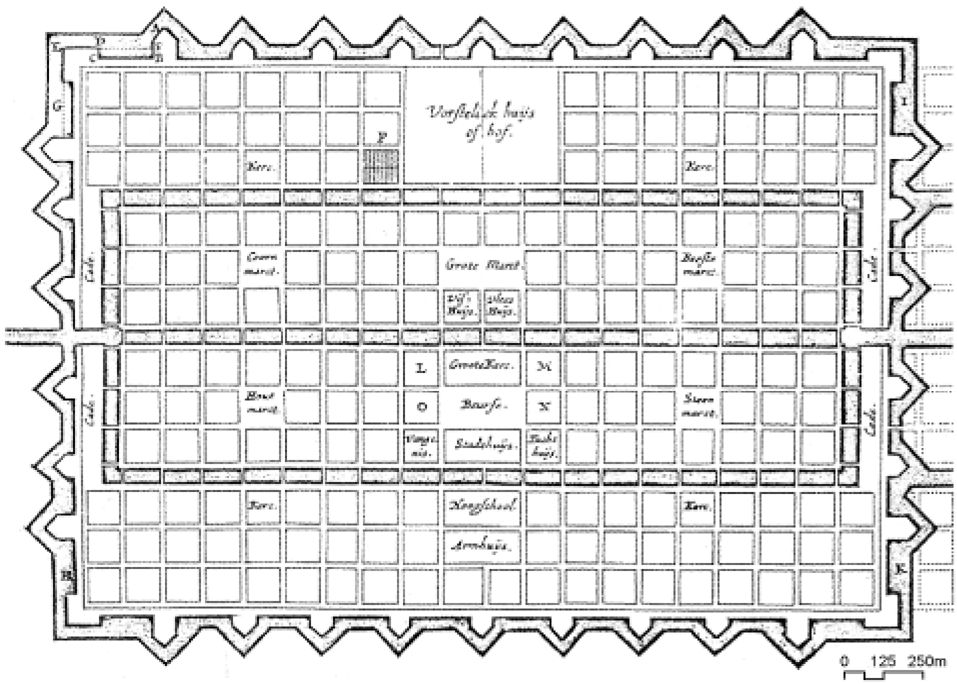


Picture 3.5 Delft in 1650 as representative of a spider in the water web, with the polder pattern establishing the master plan for urbanization.
Source: Jan Blaeu

Dutch Renaissance

The seventeenth century is a Golden Age for the Republic, when cities flourish because of economic growth; it is the period in which polder expansions are built. The cities step off their 'dry core' and, under 'strict control', raise and drain their expansions. Characteristic of this modern civil society is that the future is consciously planned on the basis of rationality, mutual consultation and decision-making. Political independence is accompanied by the flourishing of science, technology and art: the Dutch Renaissance. This is best expressed in regard to urban design by Simon Stevin's (1548-1620, an important military engineer) Ideal City, as he describes it in *Vande oirdeningh der steden* (1600, The ordening of cities). His design is based on existing principles of the size and structure of agricultural engineering and urban design. The perspectives of water management, derived from the pattern of the polders, are directly applied in his city. The socio-economical set up is directly taken from the dam town with the central market (the dam) housing the city hall and church. This is exactly what happens in the practice of city building. The term 'ideal' should not be interpreted as perfect, or idyllic, but as the model of what is considered best practice at that time. It shows what the social and territorial conditions bring about, what is best for the conditions given. This is precisely what Steenbergen and Reh define for the landscape classification of the Fine Dutch Tradition.[117]

[117] Steenbergen in an interview with the Author.



Picture 3.6 Simon Stevin's ideal City showing the dimensions of the water management system and in organization, the square in the middle containing the town hall and the church; the logic of a dam town.
Source: Van der Heuvel 2007

An important characteristic of both the Dutch Renaissance and polder cities is the result of strict control: the absence of any idealistic expression. Vision and beauty have to be paid for, and the entire budget is used to prepare the ground for city expansion. Individual citizens do not see the need for an urban composition based on central Authority, like the monumental plans in other European cities, simply because there is no central Authority in Dutch society.[118] The Dutch tradition of always trying to reach group consensus, the so called 'polder politics', is directly related to the fight against water. A count can own a lot of land, but it is useless if there are no farmers working for him to keep it dry. The farmers are well aware of this dependency and ensure that the count is also aware of their interests.[119]

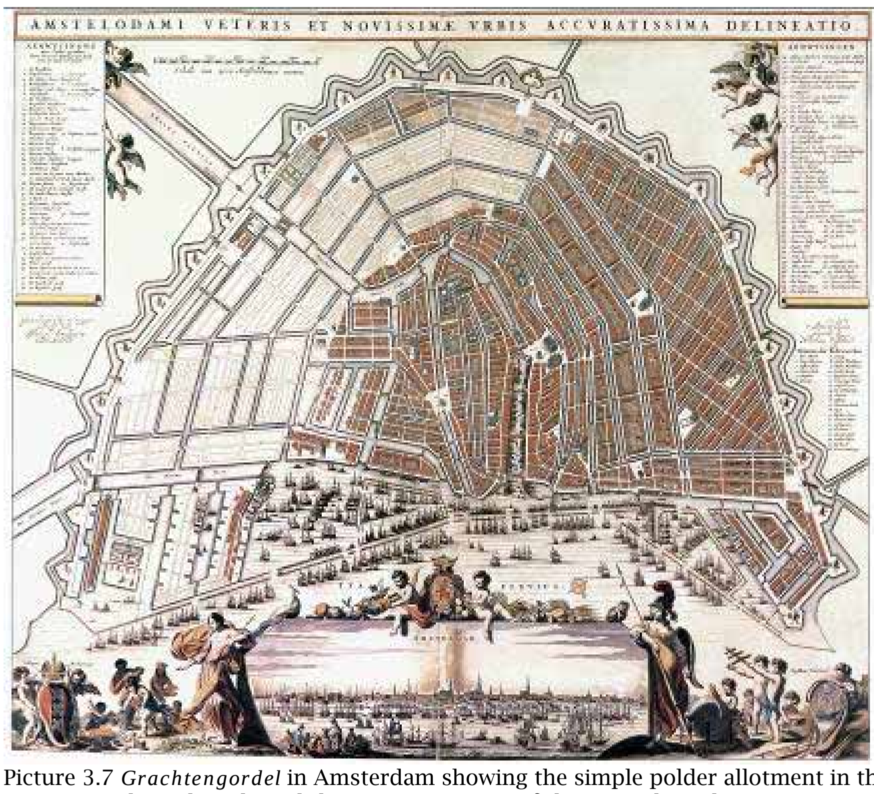
Simon Stevin's Ideal City is never built, but an urban area of the same conceptual calibre is: the *Grachtengordel* in Amsterdam (built around the 1620s). It is an integral design of land restructuring, surveying and water management undertaken with intense cooperation. Amsterdam does not try to follow the idealistic view of a capitalist city as other European cities do, but implements this design as a blueprint of social and economic life, making use of the technological possibilities.[120]

[118] De Wit 2003, 11
[119] Lendering 2005, 40
[120] Wagenaar 1993, 9 -12

Peat Polder Towns

Expansions of dry cores onto surrounding watery soil not yet suitable for building are called peat polder towns.[121] The specific characteristics of these towns are described above, with Alkmaar as the example that shows the difference between the city pattern on the dry core and in the peat polder.

The third spatial characteristic of the peat polder town, after the 'dry core' and 'strict control', is the 'close involvement in the organization and design of the peat polder landscape'. Peat polder towns are built on agricultural land, often retaining the agricultural patterns because of the fact that these patterns also represent the ownership structures. The most famous peat polder city is the *Grachtengordel* in Amsterdam, which is also the exception to the rule. Delft is an excellent example of a city where the peat polder is literally urbanized as shown in picture 3.5. Leiden, Utrecht and Haarlem also expand in the peat polder, structurally digging canals for drainage and filling the area with the material excavated from these canals supplemented with sand from outside the city, and then urbanizing the agricultural blocks.



Picture 3.7 *Grachtengordel* in Amsterdam showing the simple polder allotment in the Jordaan District on the right side and the connecting ring of three canals under construction.
Source: Municipal Archive Amsterdam

On 10 July 1609, the council of Amsterdam decides to expand the city to three times its size by digging the Keizersgracht, Prinsengracht and the Singelgracht: the *Grachtengordel*.[122] The world famous *Grachtengordel* is an

[121] Burke 1956, 33 ff.
[122] Abrahamse 2010, 41-42

integral design of a street plan and new water system and shows that the relationship between land restructuring, surveying and water management is the basis of urban development realized in the Netherlands. The design of the *Grachtengordel* is the result of cooperation between the representatives of the merchants for whom the city expansion is built, the city carpenter Hendrik Jackobzn. Staets and the surveyor Lucas Jansz. Sinck. Further study of the project shows that the *Grachtengordel* uses the dimensions of a hydrological system such as Simon Stevin's 'model' Ideal City. Apparently this is common knowledge, easily available to carpenters (the early architects). The construction of the hydrologic city is a *gesamtkunstwerk*, with shared knowledge and no boundaries.[123]

Both the canal system for draining a new city district on peat grounds and the urban traffic system are the result of the pragmatism of the military and water management conditions. The three canals are dug to drain the area (there is, therefore, a certain distance between them) and echo the position of the former city wall, the military contour. The Herengracht, already dug in 1585, is the prelude to the plan; construction of Keizersgracht, Prinsengracht and the Jordaan starts in 1612 (the third expansion). The soil excavated from the canals (together with added material such as rubbish and sand) is used to raise the land between the channels and stabilize the weak ground. Sand from the dunes and from the Gooi is also used. This is another example of the connection between city and countryside, with the city relying on sand from outside for its development. This connection is both functional and social: the merchants building houses along the canals also had estates in the Gooi. [124]

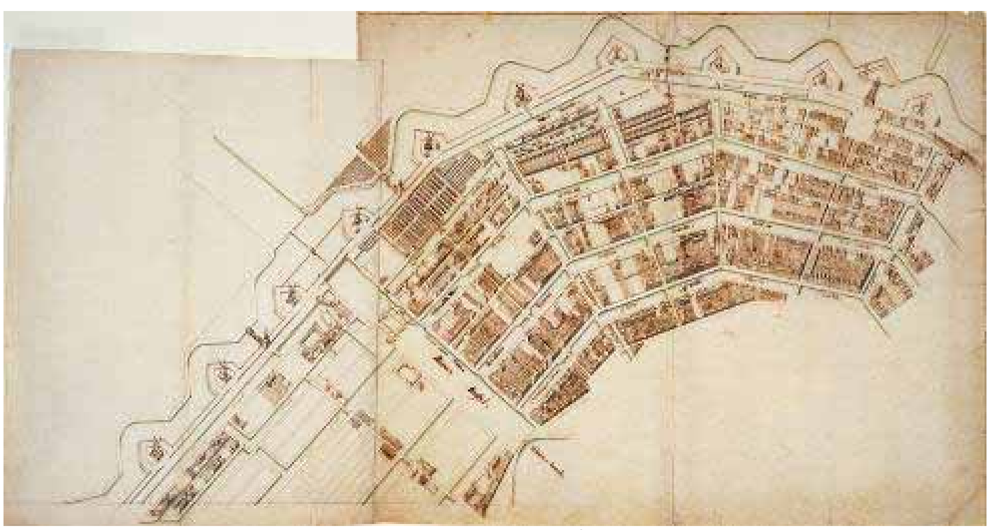
Picture 3.8 Principle of the *Grachtengordel* (around 1700) made out of roads, canals, buildings and trees.
Source: Municipal Archive Amsterdam

[123] Van der Hoeven and Louwe 1985
[124] Kloosterhuis 1956, 126-130

The fact that the three canals are positioned according to military and water management rules (but not the peat polder pattern) represents the consciousness of the city about ideal form and elegance and this makes the *Grachtengordel* an excellent example of the combination between water management and city building: urban engineering.

In the Jordaan, for reasons of speed and economy, the polder or hydrologic structure is used as a master plan. Here, half of the polder ditches are expanded into canals and the other half are filled in and used as back streets. The simplicity of the plan corresponds with the minimum financial outlay intended for this city development, which would house religious fugitives (reformed) from the southern Netherlands. The new expansion between the three canals is somewhat lower than the earlier steps in the making of Amsterdam in the Middle Ages and mills were built to control the water system. In the Jordaan the level is even lower, representing the socioeconomic connection with building site preparation: filling the ground level is costly and poorer areas in many Dutch towns are therefore kept low.[125] The quality of the Jordaan contrasts sharply with the new residential and commercial areas of the regents and traders: the *Grachtengordel*.

The design represents the technical possibility of realizing this 'machinery of civil engineering works', and the level of ambition and social status of the patrons and inhabitants. The *Grachtengordel* is an expression originating from the Dutch Renaissance. It is based on a rectangular plot division in which roads, canals, buildings and trees are included along with the different social classes. Equality of the people along the canal is illustrated by the composition of the three canals. The actual realization of the *Grachtengordel* is the acknowledgment of the involvement of private companies and the fact that it is the blueprint for seventeenth-century society.[126]

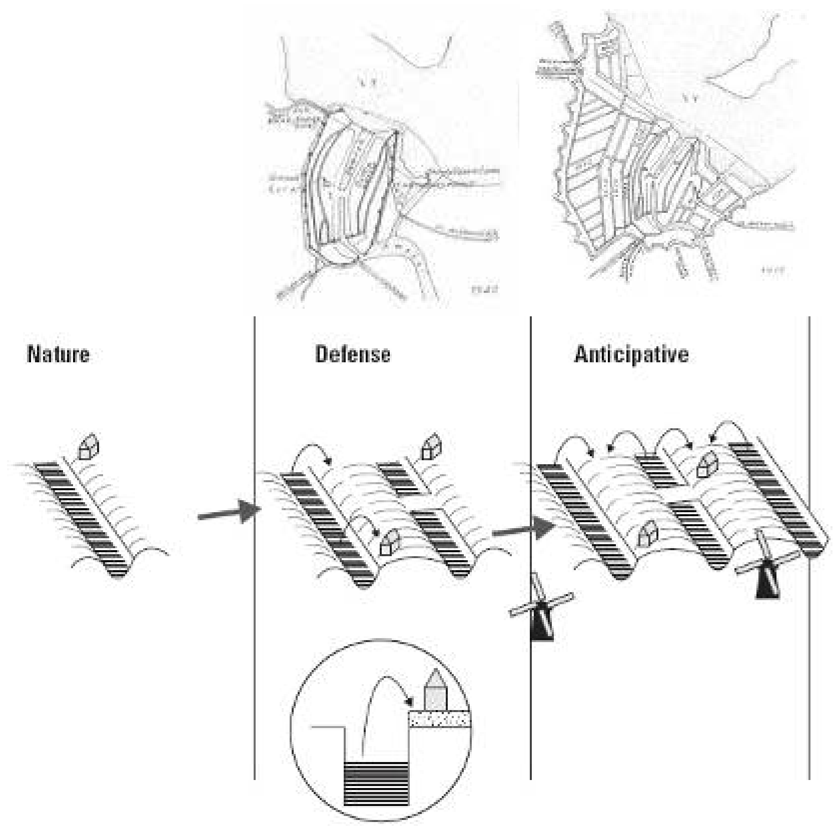


Picture 3.9 Jacob Bosch in 1679 showing the last part of Amsterdam's expansion: the urban concept.
Source: Municipal Archive Amsterdam

125 Abrahamse 2010, 298
126 Mumford 1961

The publication of an architecture-historical investigation into the *Grachtengordel* offers a lot of context and information about the Phase of the Anticipative attitude towards the natural system. *De Grote Uitleg van Amsterdam* (the great Amsterdam city expansion) by Jaap Evert Abrahamse describes the administrative process of designing, financing and engineering the great semicircular canal system, the *Grachtengordel*. For this research he used only primary sources: maps and *vroedschapsresoluties*[127].

The main proof this investigation offers is that the *Grachtengordel* is not an idealistic plan, like others executed at the time, but grows in four steps. Abrahamse demonstrates that the third step in the expansion of Amsterdam (1612) is the 'learning' step, when the urban principle becomes 'urban planning'. The fourth city extension (ca. 1660) is a resounding success with new design, planning and execution methods. It is the result of the development of a method that makes the best of functionality and aesthetics with maximal land prices.[128] The urban plan is an ongoing interplay between ground and intervention that designs a coherent system of fortification, water management, infrastructure and allotment. That is urban design.[129]



Picture 3.10 From step to principle to concept of planning.
Source: Author, drawn by Stella Smienk

[127] The resolutions of the Mayor and Executive Board of the municipalily.
[128] Abrahamse 2010, 157
[129] Taverne 1993, 9

Here the development of the Fine Dutch Tradition is touched upon, although not mentioned, and urban development is described as being the combination of urban design, water management and urban management. Abrahamse defines the expansion of Amsterdam as a unique urban design challenge due to the strong urban growth it has to answer to and the dynamic landscape where it is to be built and the necessity for man to intervene in this natural system. He shows that the physical geographical situation cannot be handled by private developers but is a task for the public office. [130]

The most interesting point Abrahamse makes is that city development is all about functionality, aesthetics and financial efficiency. He determines them as strongly intertwined characteristics that deal with the conditions of population growth, landscape allotment, fortification system and water management. The combination of water management and the soil conditions force according to Abrahamse a large-scale and prominently directed development, new to seventeenth century city development.[131] The urban principles that direct the development of the old core are: radial streets and cart quarters, canals and the urbanized polder structure. These elements are transformed (under influence of international used norms) into more regular form and applied at the higher scale of the urban plan.

Abrahamse explains that the fortification design is disconnected from the city design and is therefore leading in designing the contours and connecting infrastructure to the hinterland of the urban plan.[132] Thus the municipality lays out the fortifications and then the urban plan follows, in the case of the *Grachtengordel* the properties are expropriated and the development is also done by the municipality, this was then filled in by private developers. For the urban plan there is an investigation into how the existing landscape can be attuned to the property positions and the most efficient plot division, resulting in a situation in which the landscape pattern is not used.[133] Abrahamse concludes that the integral plan combining functions, infrastructure, urban design and water management triumphs over the short-term strategy in which the costs are reduced by using the landscape pattern. The fact that the rules of the natural system, of the water system, still determine the dimensions of the expansions is beyond his horizon.[134] He also considers only the water surface as part of the water system and sees the canals as an urban concept and not a matter of wet or dry land.[135]

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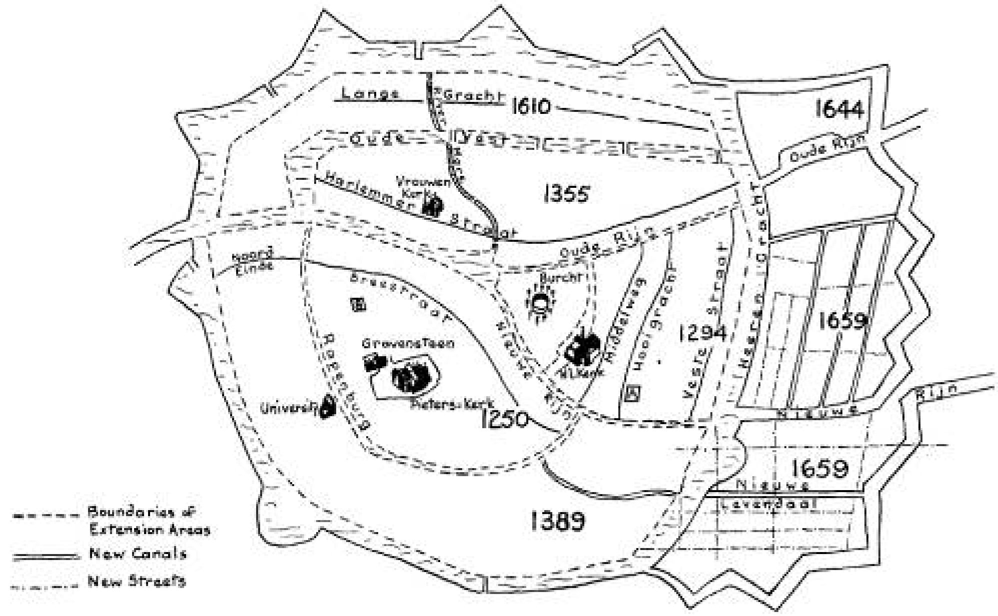
[130] Abrahamse 2010, 334
[131] Abrahamse 2010, 338-339
[132] Abrahamse 2010, 340
[133] Abrahamse 2010, 344
[134] Abrahamse 2010, 345
[135] Abrahamse 2010, 157



Picture 3.11 The development of Leiden
Source: Burke 1956

The expansions of Leiden, Haarlem and Utrecht all use a mathematical system of canals, quays and fortifications as their main urban structure. The reasons for the expansions are the housing shortage, improvement of the existing city and water management issues. The best balance between optimal use of the grounds for fortification and housing, and canals for drainage, discharge and transport is aimed at: efficiency. The study by Taverne explains that there are influences that have a negative effect on the quality of the expansions, like the high demand for land, high land prices, the costs of an expansion (fortifications and expropriation) and the chance that the land will not be sold after being prepared for building. Taverne does mention the fact that the land needed draining but does not identify this fact as crucial in the characteristic of urban planning in the Netherlands in the seventeenth century.[136]

But as Taverne has shown, in the end the money makes the difference for the urban plan. Taverne has studied the different proposals by Jan Pietersz. Dou (1611 and 1658) for Leiden,[137]
Hendrick Moreelse (between 1624 and 1672) and Bernard de Roy (1670) for Utrecht,[138] and for Haarlem by Pieter Wils (1643).[139] In all of these case studies the plans are discussed without reference to the canal systems; even though Taverne does investigate the dimensions of the systems and the socioeconomic background of the plans, he does not explain why there are always canals in the plans. He takes them for granted, while the dimensions – with or without canals – and the technical and socioeconomic importance of the canals are, to him, crucial.

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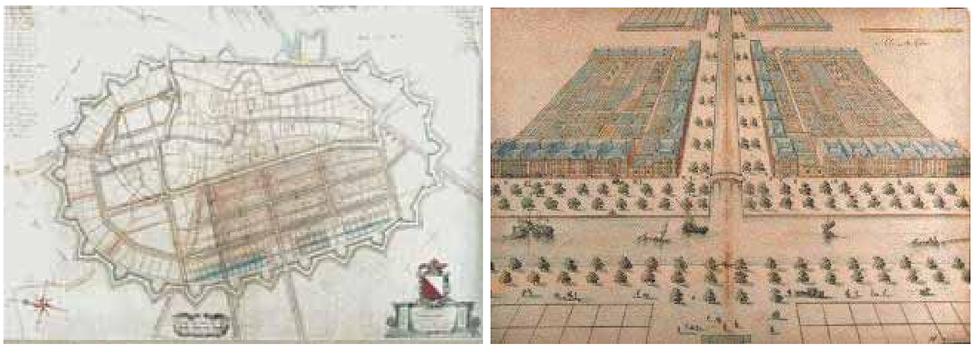
[136] Taverne 1978, 113-115
[137] Taverne 1978, 189-237
[138] Taverne 1978, 238 e.v.
[139] Taverne 1978, 279 e.v.

As mentioned in the introduction the Dutch engineers are very much inspired by the Italians and it is no accident that the last two plans for Utrecht and Haarlem resembled Italian Vincenzo Scamozzi's *Citta Ideale* (1615). This Ideal City, like Simon Stevins' Ideal City, shows a logical approach towards the division between private and public space – an issue, when considering money, which is wrestled with when making all these plans, especially in combination with the demands for fortification, the canal system and enough ground for the necessary housing.



Picture 3.12 The plan of Utrecht according to Moreelse.
Source: Municipal Archive Utrecht (Aj 1.1.1- K 0.069 and Aj 1.1.2 - K 0.0770)

Rotterdam Waterstad

The fall of Antwerp in 1585 signifies an important boost for the economic, social and cultural life of the Northern Netherlands. Because the United Provinces of the Netherlands (1588) starts using Rotterdam as its most important port, Rotterdam expands. Amsterdam had been the favoured port up to that point, but since Amsterdam courted the friendship of the Spanish conquerors (1568-1648) it is no longer trusted. What is more, Rotterdam is geographically more suitably located. It is a safe and sheltered location close to the North Sea, and the Maas provides an excellent route to the German hinterland. Deep harbour docks can be carved out of the riverbed. And Rotterdam is situated along the route from Amsterdam to Antwerp and thus can profit from both markets.[140]

The flourishing harbour activities make people favour the water side over the land side in Rotterdam. The surrounding peat polders are very wet and for the relatively poor city very expensive to develop.[141] The drainage affected by the ditches makes the peat oxidize and shrink, the polders subside. At the beginning of the fifteenth century in the area of the Schieland Water Board, no mills are yet used to pump water. In the course of the fifteenth century the peat polders become so low in comparison to the *boezems* Rotte and Schie that a system of dikes is built and the water in those sections is pumped by mills into the *boezems*. The invention of the mill as a pumping device brings about other different projects such as drying lakes to create agricultural land. Areas connected to the Rotte are

[140] Van Ravesteyn 1928,140
[141] Van Ravesteyn 1928,124

Polder Honderdtien Morgen (1646), Binnenwegse Polder (1700), Polder Honderdveertig Morgen (1715), Tweemanspolder (1727), Eendragtspolder (1752) and Polder Bleiswijk (1765). The use of pumps becomes more and more important; by the sixteenth century 17 mills are used to pump polder water into the Rotte. Control over the water is dependent on metrological circumstances. In the seventeenth century people complain about the bad discharge due to the wind (pushing the water in the wrong direction) and the high level of the water in the Maas. From 1742 a mill is placed to pump the water from the *boezem* in the Maas and later the Hoge Boezem is built (1772) as an extra step in the system for an even better regulation of the water level (in 1899 this is replaced by a steam engine).[142]

Picture 3.13 Rotterdam in the seventeenth century
Source: Municipal Archive Rotterdam

Expertise about wet land and methods for drainage is not yet concentrated and widely spread. In Rotterdam this knowledge is first gathered at the *Stadstimmerhuis*. This ‘house of the city’s carpenter’, where public works are designed and developed, is first mentioned in 1545. Rotterdam being a very small settlement, it is probably not on a very large scale. At the end of the sixteenth century, when *Waterstad* is built, there are still only a few people working in the Stadstimmerhuis, although there are many contracted workers.[143]

The first city architect is Claesz Jeremiasz Persoons, appointed because

[142] Peilbesluit Rotte Toelichting06-09-05, Vastgesteld door VV op 28 september 2005, Goedgekeurd door GS op, Versie 3 (gelijk aan 14 december 2004), Rotterdam, 23 augustus 2005, kenmerk 2004.10528,
[143] Nieuwenhuis 1955, 7

of his ingenious solution for the tower of the St Laurens church that, due to the soft soil, almost fell over.[144] The city had asked the great architect Jacob van Campen for advice but he did not provide a solution to the problem. Persoons, master bricklayer, successor of both the city carpenter and the city bricklayer, is appointed in 1660. The department is called *stadsfabricage*, which can be directly translated as 'city fabrication'; Persoons is clearly in charge of making the city.[145]

So instead of building in the sinking peat polder, the people of Rotterdam decide to expand the city into the Maas. By the thirteenth century the *aanwas*, a silted up part of the river close to the shore, outside the dike are already being used for harbour activities.[146] It starts with the building of houses on the riverside of the Blaak harbour in 1575, the *aanwas* is developed in the sixteenth century for the trade and shipping industry. The *aanwas* in front of the city named Nieuwland (new land) is given a dike ring on the eastern side so the first settlements are protected from the river at high tide. The new polder is drained by a ditch called Zijl, which in Dutch means: a ditch that drains a polder. The layout of Nieuwland is very simple and before the sixteenth and seventeenth century there is no actual underlying plan for the development. The houses grow together following the shape of the river and the harbours. Parts are inside the dikes and parts are outside, making dikes an important urban element in the layout.[147]

Between 1575 and 1615 the area outside the dikes is annexed. Until then the Blaak harbour is the most southerly point of the settlement. Two canals, the later Leuvehaven and Oude Haven, provide access to the town. The excavated mud is used to make new land along the waterfront.[148] After 1577 plots of land to the south of Blaak harbour are released as building sites. In 1613 Wijnhaven (wine harbour) and Scheepmakershaven (ship builders' harbour) are dug as ship berths and as sites for shipyards. The development is done with a view to the future because the harbours are large enough to suffice until the nineteenth century. The fact that the people of Rotterdam choose then to dig 65-m harbours shows fortitude and foresight.[149] By 1619 Rotterdam already has 32 bridges outside the dike.

The allotment of the area is – considering the grandness of the harbour plan and compared to the allotment in Amsterdam – very poor. Because building foundations is quite expensive and the budgets are small, the building lots are small-scale. Additionally, the demand for building lots is high. Apparently the city conditions are such that it is easier, or cheaper, to build in the river.[150]

The building lots in Rotterdam are much smaller than those in Amsterdam, making a less monumental cityscape. The reason for this is that the houses and the quays on the harbour (which the owners have to construct and maintain) are quite expensive; the foundations and structures necessary in Rotterdam are more extensive than those in Amsterdam. The costs of building and maintaining a water city are reflected in the size of the

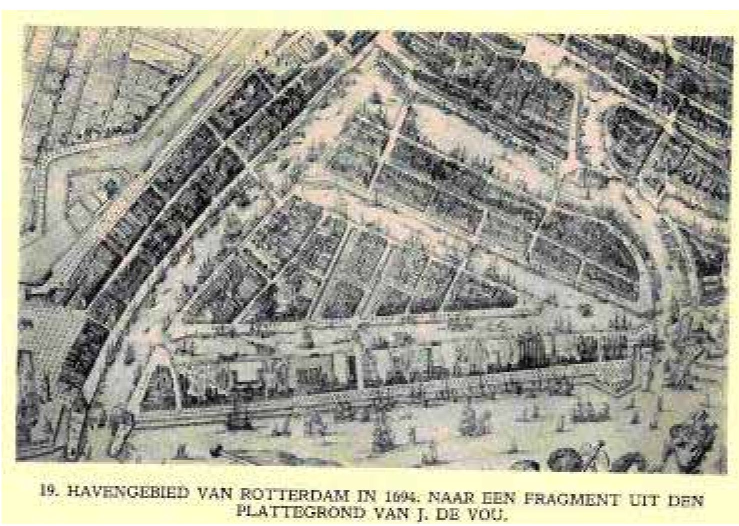
[144] What this solution is, remains unclear.
[145] Nieuwenhuis, 1955, 9
[146] Van Ravesteyn 1928, 105
[147] Van Ravesteyn 1929, 22
[148] Van Ravesteyn 1929, 33
[149] Van Ravesteyn 1929, 35
[150] Van Ravesteyn 1929, 17

building lots, the large sizes in Amsterdam show two things: the superior territorial conditions and the wealth of the Amsterdam citizens.[151] The people who develop the land are responsible for the costs according to old Dutch rules: *dien ‘t water deert, die ‘t water keert* (he who is bothered by the water, is he who puts up the defence), *die medeweteren wil moet medegelden* (whoever wants to rule has to pay), *die bekostigd die beheert* (he who pays is he who manages).[152]

In 1613, 117 plots located along the river between Leuvehaven and Oude Haven are exclusively earmarked by the city fathers as sites for shipyards. Two years earlier the Boompjes (little trees) quay had been built. The first building on the Boompjes dates from 1614, and the following year a double row of lime trees is planted along the water’s edge giving the quay its name. These trees make the quay a suitable promenade and also serve as a wood supply in case of war. A line of stakes in the Maas in front of the Boompjes both fortifies the quay and protects it from waves. Accordingly, vessels cannot moor directly on the quay. Barriers across the two harbour entrances at Ooster- and Wester Oudehoofdpoort prevent unwanted visitors from gaining entrance to the city.

The new town quarter is appropriately called *Waterstad* (water city). A bustling centre of shipyards, warehouses, sail-making, rope-making and later grand merchants’ houses develops around Scheepmakershaven and Wijnhaven. The development of the area reflects the economic and political strength of Rotterdam.[153]

Over the course of the seventeenth century, merchants increasingly come to see *Waterstad* as a pleasant district in which to work and live. Since *Waterstad* is situated outside the dike it is regularly flooded. Representative spaces in the buildings therefore have to be located on the first floor. In contrast with the densely built-up city triangle, *Waterstad* is spacious and comfortable.

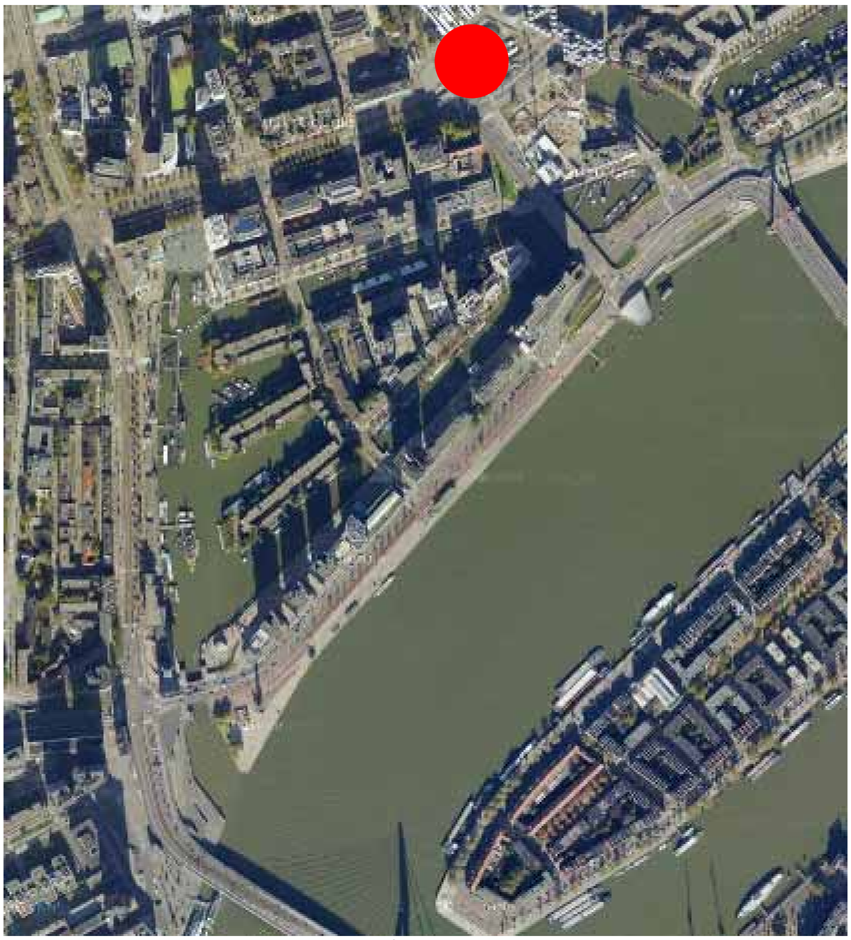


Picture 3.14 *Waterstad* in 1694
Source: De Vou, Municipal Archive Rotterdam

[151] Van Ravesteyn 1929, 37
[152] Van Ravesteyn 1928, 105
[153] Van Ravesteyn 1929, 37

Rotterdam Waterstad in 2011

During the bombing of 14 May 1940, *Waterstad* is for the greater part destroyed. In the same year the rubble is cleared and used to fill in several canals and harbours such as Blaak, Oppert and Botersloot. The whole area of *Waterstad* is raised with sand. The primary dike situated at Hoogstraat is moved in the 1960s towards the waterfront along the Maas. *Waterstad* is now located behind the dikes and protected by the main defence system.



Picture 3.15 Waterstad in the twenty-first century, the red circle is the old dam.
Source: Google Earth

W.G. Witteveen's first plans for the reconstruction of the city show little alteration of *Waterstad* as it was, because Witteveen respects the waterscape as an element of beauty. His successor Van Traa, however, alters its character by widening the Leuvehaven and making the small triangle accessible only from the north side. In the Basic Plan of 1946, Van Traa and his cohorts turn all of their attention on a new phenomenon: the 'window on the river', an urban concept that is meant to give meaning to the Leuvehaven as a link between the Coolsingel and the Maas River. In Witteveen's plan, the relationship between the city and the river is based on the pre-war situation and *Waterstad*, with the oldest harbour basins in Rotterdam, remains a platform for companies allied to trade and shipping.[154]

Coolsingel in the Basic Plan is made to curve somewhat to the east – contiguous with Schiedamsedijk – to create space at the head of Leuvehaven. This indeed gives the city a view of the river. The remains of Dudok's celebrated Bijenkorf department store are demolished to make space for a plaza overlooking Leuvehaven. This harbour basin is graced with a broad quay on two levels: one for moored vessels, the other for promenades. Chunky 'reconstruction buildings' accompany the walk along the Maas. Thirty years on, the construction of the Maritime Museum once again erases the sight line from Coolsingel to the Maas. All the same, the 'window on the river' gives a major boost to post-war thinking on the relationship between city and river.[155]

The area is first filled mainly with office buildings and some apartments. However, the harbour function in the Leuvehaven does not develop as expected. Instead of the 30,000 vessels for which the harbour is designed, in 1951 only 4,000 stop in the Leuvehaven. In the following years that number even decreases. Activities move towards the Botlek and the Leuvehaven becomes a silent, empty harbour. In 1968 sociologist R. Wentholt researches the experience of the inner city. The Leuvehaven in particular is not rated very highly as a comfortable urban place and Wentholt suggests that only large-scale housing can change the perception of the empty islands along the Leuvehaven.[156] J. Hoogstad designs a master plan for the area with a museum, a small trading centre and housing. In his plan bridges over the harbours assure accessibility to the area. In 1975 a report about the restructuring of old harbours is published which proposes that these areas be used for housing, recreation and culture. From 1976 to 1980 (social) housing is realized on the three piers in the Leuvehaven by architect A.J. ter Braak, but the connection between the piers is never built. The Maritime Museum, designed by architect W. Quist, is built in 1980 on the corner of the Leuvehaven and Schiedamsedijk.[157]

The relation between city and river is lost when the dike is moved towards the Maas in the 1960s. The road and the high buildings constructed on the dike do not improve this relationship. It has been partly recovered by the Maritime Museum and the classical boats moored in the Leuvehaven, and the landing pier of the water taxi that plies the river also makes it more a part of the city. Some development is done in the area, most of the post-war office buildings are replaced by high towers with luxurious housing. Restoring the relationship between city and river has been a subject of study for several years, not only concerning the Leuvehaven but especially geared towards the Boompjes and how to once again make it into the city front it was before the Second World War.[158]

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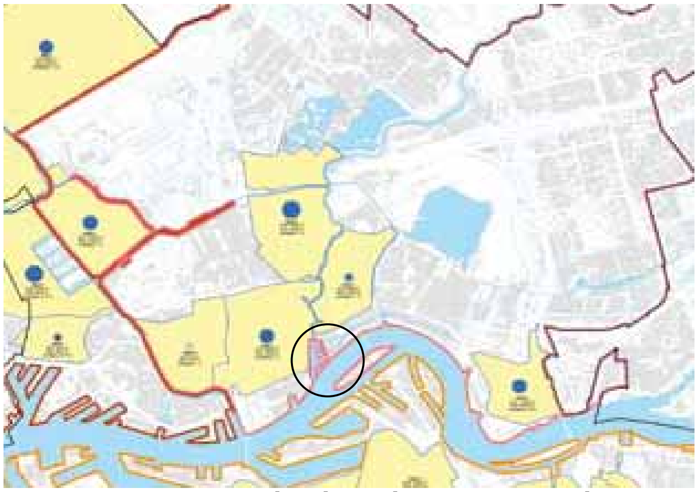
[154] Schadee 2000, 444-445
[155] Schadee 2000, 442
[156] Wentholt 1968, 125
[157] Schadee 2000, 451-453
[158] One of the large studies into this challenge is done in the framework of Rotterdam Cultural Capital of Europe 2001, see the publication: Duursma 2001



Picture 3.16 *Waterstad* within the quality map in Waterplan 2.
Source: Waterplan 2

Finally, evaluating *Waterstad* on its current performance within the water challenge of Rotterdam using the information given in the *Waterplan 2* (2007) there is no quantity and no quality issue. Only in the future, with rising sea levels, might some reinforcement be needed.[159]

The Fine Dutch Tradition: Episode Two

The mill marks the transition towards an Offensive Phase in the attitude towards nature. The Netherlands in the seventeenth and eighteenth century is attractive because of its landscape, towns, parks, buildings, and because everything in the country seems to be vital and alive. The Dutch Golden Century produces great prosperity, and a new modern form of social coherence that is characterized by unity and diversity.[160] The power of unity is evident in the building of beautiful hydrological (water) cities. It is the Phase in which the Dutch planning tradition is born, defining the genius of cooperation, looking ahead, and balancing nature and culture. The paradigm that accompanies the Phase of the Anticipative attitude towards nature is *fertility*. It stands for making the best of all of the territory's potentials (and anticipating future ones) and dealing with the threats of nature. It is characterized by an inventive attitude that is based on cooperation and the combination of challanges and solutions and this is illustrated by the polder city.

The mill marks the change towards an Anticipative attitude and changes the relation between urbanization, the landscape and technology. The spatial characteristics of the peat polder cities define the Fine Dutch Tradition: dry core, strict control and relation to the landscape. The physical relationship between the landscape and urban design remains very strong, the rules of water management and the landscape are still the basis for city development. The dry core is the economic and social centre where the development of knowledge takes place. The strict control represents the fact

[159] Gemeente Rotterdam et al. 2007
[160] Blom 2005, 366-376

that conscious interventions are made; one does not 'simply' follow the established path. This corresponds to the characteristics of the Dutch Renaissance of consciously planning on the basis of rationality, mutual consult and decision-making and the absence of any idealistic expression. The strong relationship with the landscape is not only morphologically the case, but also in military technology where the use of readily available material is preferred. The ultimate expression of this is the Ideal City by Simon Stevin; not ideal for being a model, but in reflecting the practice of the making of Dutch towns. According to Taverne it offers a contribution to the urban design method.[161]

The influence of the military engineer is major: fortifications are built following the example of the Italian Renaissance, where the use of available materials is preferred. In the Netherlands military engineers use mud and water to build ramparts and moats. This strengthens the relationship with the landscape on the borders of the cities and within the cities there is a morphological connection to the landscape because of hydrology.

The mathematical language of the military engineers evident in Simon Stevin's Ideal City is also the language of surveyors. It describes the dimensions of the water system that can be connected to the scale of the new urban plans that are created. The water system, building site preparation and urban development all become of one scale and one language and the urban principle transforms into an urban plan.

The two main examples used in this chapter, the *Grachtengordel* and *Waterstad*, are the odd ones out in the regular practice seen in other cities like Haarlem, Leiden en Utrecht. The *Grachtengordel* does not follow the physical geographic patterns (the peat polder structure) and *Waterstad* is not a polder city but built outside the dikes. What both do reflect is the important new function of water and the ability to render poor soil fertile by the use of technology. In Rotterdam the relation between the design of the expansion and the landscape, and the relation between design and technology, are both very strong. The shape of the islands is directly taken from the existing river banks and cut through with harbours. The curve in the river is used as the outer boundary fortified with a quay and a boulevard. Even though the three canals of the *Grachtengordel* do not follow the physical geography, they do represent the technology of balancing water and land that is necessary to build a peat polder city.

Especially the study by Abrahamse gives insight into how the 'design' of the *Grachtengordel* is the result of how the expansion is made, how the principle of digging a canal to make buildable land becomes an urban concept. His research was done in part in reaction to Taverne's dissertation (1978) *In 't land van belofte*, which he considered to be a bad review of the *Grachtengordel*. He shows that the ideal city plan as a touchstone and the idea of master planning (which in Taverne's opinion were missing) are part of an anachronism. Taverne, according to Abrahamse, blames the builders of the *Grachtengordel* for doing what they always did: appropriate, make fortifications and building lots, and then sell the lots.[162] Taverne corrected his anachronism years later and argued that the citizens of Amsterdam (and

[161] Taverne 1990, 5
[162] Abrahamse 2010, 28-29

he includes Simon Stevin in this) were not aiming at an end image, but were developing a skill, a technique, a practice of surveying, the experience of water management and landscaping. These traditional techniques are at the base of the shape of the *Grachtengordel.* The design represents the technological possibility to realize this 'machinery of civil engineering works', and the level of ambition and social status of the principals and inhabitants: the Dutch Renaissance.

The mental relationship changes due to the fact that more control is gained. Thus sometimes the landscape is altered, like the *Grachtengordel,* by means of building site preparation: altering the balance between water and land in such a way that the site can be used for urbanization. The shape of the city reflects the necessity for social coherence, military conditions and the organization of public works to enable these plans to be realized. These are the characteristics of the Fine Dutch Tradition formed during these centuries, the ultimate example being Simon Stevin's Ideal City.

Chapter 4: New Power (1800-1890)

Urbanization and industrialization

The Phase starting in the nineteenth century is characterized by an exploding population growth and industrialization. The transformation from manual to machine labour is made possible by the introduction of the steam engine. The first Industrial Revolution takes place between 1800 and 1850; principally in cotton-based technology (spinning, weaving, and so forth). The second Industrial Revolution, from 1850 to 1900, is characterised by: railways, shipping, and heavy industry producing iron and steel. Besides strongly altering the forces that shape the (urban) landscape, this is when industrialization arrives in the Netherlands. The Industrial Revolution also effects changes in hydraulic and hydrologic technology.

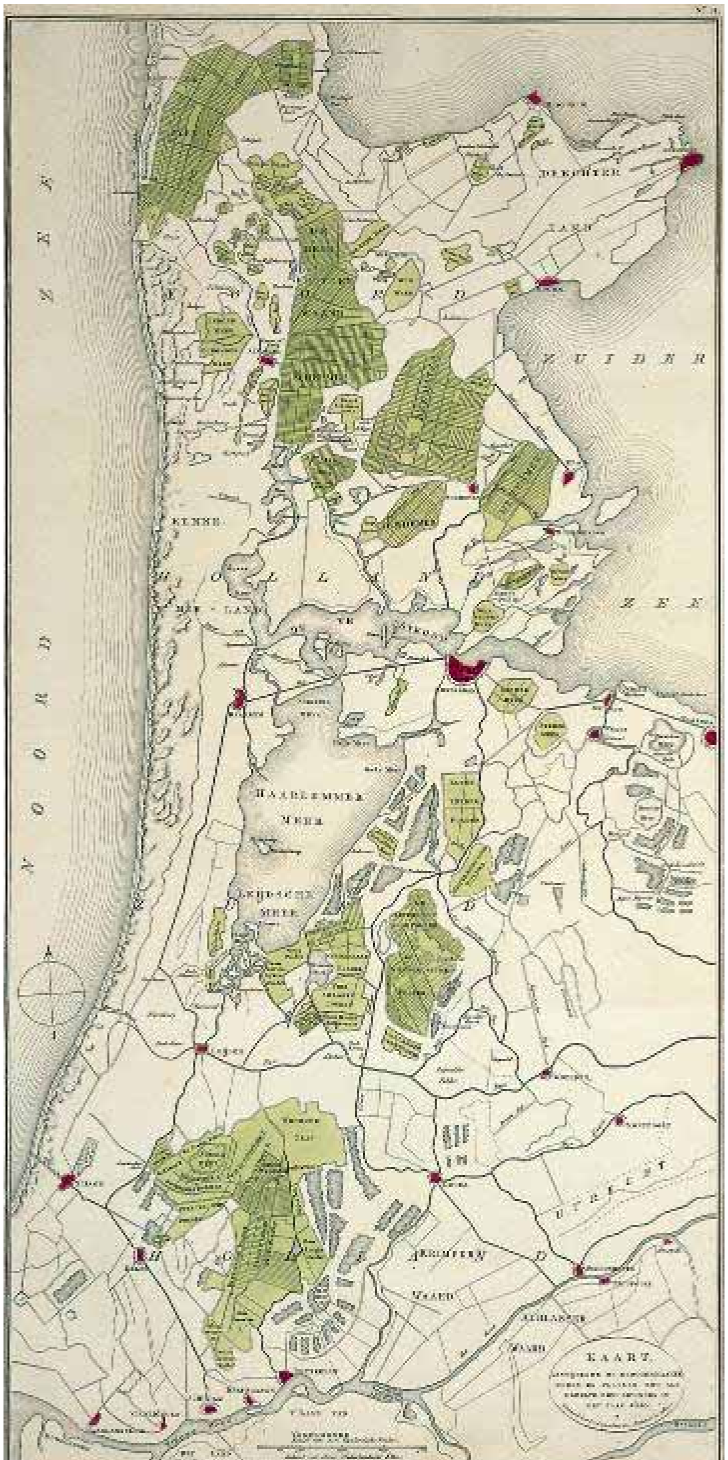
The basic technology of the steam engine is developed in England in the early eighteenth century, but as with all new technology it takes some time to be adopted in the Netherlands. It is first introduced in Rotterdam in 1787 in the shape of a water pumping station that controls the water level in the polder Blijdorp. As there is no infrastructure for maintenance and repair it takes a long time for the steam engine to become widely used: all technicians in the first decades have to come from England.

This era of urbanization and the development of high-tempo processes by machines is characterized by the principle of systemization. French domination brings social systemization; in administrative organization, the monarch brings the monarchical order; the Industrial Revolution brings new faster systems of production; the train enforces time tables that are actually executed and speed up life.

Systemization is also applied to the development of knowledge. Under the influence of the ideas of the Age of Enlightenment the scientific approach, for example towards issues of nature, is enforced. The organization of this demand for scientific knowledge in water management follows the French model and leads to large-scale water works such as digging new river beds, normalizing rivers, damming larger waters, pumping lakes dry and maintaining artificial water levels.

Waterworks start to shape the Dutch landscape on a larger scale than in the preceding 900 years, clear signs of the Offensive attitude towards the natural system. The establishment of the national state, the role of the king as a stimulator of large waterprojets like canals, and all the new technological possibilities for realising such waterprojects, contributed to the widely shared view that water could become an economic motor and, as a result, it became a national interest. An important example of both these aspects of water management is realized by King Willem I ordering the digging of many channels.[163]

[163] See the publication by R. Filarski 1995



Picture 4.1 Holland in 1820 showing the cities as spiders in the water web and in green the drained lakes.
Source: Koninklijke Bibiotheek Den Haag

By the end of the eighteenth century these large-scale projects (rivers, channels and dried lakes like the Haarlemmermeer) give the engineer a visible status and a more defined discipline (with clear tasks, education and a discourse). After 1842, military engineers are slowly replaced by civil engineers trained in Delft. Special courses for architects are also started here; the faculty of architecture is founded in 1905.

The practice of city building can be defined as urban engineering wherein the landscape (as a carrier of the hydrological system) still functions as the master plan. This, it will be argued in this chapter, describes the case of the *Waterproject* in Rotterdam, which is the first large-scale city expansion in the Netherlands since the Golden Age. After the Golden Age a period of economic and political decline under Spanish and later French domination persists until 1814, when the monarchy is founded, and the period of 'urbanization silence' ends around 1850. The basic types of water town, extended with fortifications, polder, or both, retain their characteristic urban form until well into the nineteenth century. The expansion of Rotterdam in the mid-nineteenth century also introduces the change from building for specific clients to building for the market (anonymous clients).

Picture 4.2 Here new power meets old power brining prosperity in the Netherlands: the new rail way bridge over the Delftshavense Schie near Rotterdam. Painted by Charles Rochussen (1814-1894) in 1851.
Source: Spoorwegmuseum Utrecht

Because clients are anonymous, and to keep prices low, the quality of the houses decreases and the term 'private builder' acquires a negative connotation. There is not much consideration for hygiene in the houses, which are stacked together and lack light and air. Again the engineer becomes a player in solving these issues at the end of the nineteenth century.

Light and air are issues on an urban scale, the houses packed together along small unpaved streets without sewers result in a very bad hygienic situation. For this reason the closed city type of the former Phase is altered to the open city type, where houses can be built in wider streets, providing them with the necessary light and air.

At the end of the Offensive Phase, air, light, waste and with them the introduction of large-scale infrastructures like the sewer and the railway can be seen as the first *grande* issues on the scale of urban design.

The urban strategy connected to these issues is one of 'functional concentration'. The spatial organization of cities in the nineteenth century is characterized by the separation of conflicting functions and the bundling of functions that belong together.[164] This is all planned by the Department of Public Works and executed by professionalized technicians. Urban design in these developments becomes increasingly more technical rather than administrative. The ideas about urban design become of secondary importance and decline into a technical profession.

This chapter is about the Modern Era, which is characterized by a new state of mind, new technology, new knowledge development, new national and urban organization; all representing the paradigm of systemization. This is manifested in the new city type that opens up to the landscape and wherein functional separation is started. This era does not end, but accelerates after 1890 when systemization slowly turns into *maakbaarheid*, the idea that man can make everything possible and control everything. The example for this Phase is Willem Nicolaas Rose and the expansion of Rotterdam with the *Waterproject*, which combines water management with urban vision and integrates four urban challenges. This chapter will also show that yet again the water challenge demands urban design. Besides the *Waterproject*, this is illustrated by the expansions of Amsterdam and the redevelopment of fortifications in other cities.

Van der Woud (1987) Het lege land

When studying the relation between water management and urban design in the nineteenth century, reading the dissertation of Auke van der Woud, *Het lege land* (the empty land), is frustrating while simultaneously evoking admiration for his accomplishment in making water a self-evident part of spatial order. Van der Woud explains:

> Spatial order is an abstract term with analogies to cosmic order, social order, economical order and juristic order. It proposes an internal coherence, a certain construction, consciously made by humans or not. This order can be so complex by nature that it can be a paradox, chaotic and difficult to understand. Spatial development and form can be a part of the spatial order, the material part. The order itself, however, is more than material and contains next to the human-made elements like bridges, the polder level, the cities, the dikes, also the deformed, the chance growth of shapes, and next to the built also decay, next to what is measurable and weighable also the relative relationship between space and time, speed and slowness, mobility and stagnation.[165]

Van der Woud investigates the relation of the spatial order to the social, economic and legislative orders of which, in his vision, architecture and urban design are the spatial expression. In this way he connects society and urban design in the nineteenth century and clarifies the birth of urban planning in the Netherlands. He studies the connections between the fields

[164] Van der Woud 1987, 346
[165] Van der Woud 1987, 15-16

of knowledge of economy, law, water construction, geology, demography, medicine, sociopsychology, climatology, urban and architectural design, the military, politics and policy, and the expression of these in spatial objects, to demonstrate the coherence between these elements.

In his studies Van der Woud uses the historic method of Fernand Braudel, which leads to the concept of his book: the architectural and urban design of the nineteenth century must represent a deep, global historical structure or combination of structures.[166] *Het Lege Land* is all about water management and urbanism – however implicit – and offers for this research the full context of the Offensive Phase for three reasons.

The first is his conclusion that 'time and time again water management is an aspect of high importance that influenced the spatial order (on all scale levels)'.[167] According to Van der Woud, in any research into the spatial order of the Netherlands it is immediately apparent that the consideration of the existence of the dikes is a *conditio sine qua non*. Without dikes there is no spatial order because there is no land on which to impose it.[168] Van der Woud presents three examples from the Offensive Phase to substantiate this argument: the causal relation between climate change and the exploration of the possibilities of intervening in the water system, the redesign of the city ramparts in the nineteenth century and the new villages in the reclaimed polders.

The first example, the causal relation between climate change and the exploration of the possibilities of intervening in the water system, is illustrated by the systematic defence of building dikes in the seventeenth and nineteenth centuries in anticipation of the subsidence of the land. In the nineteenth century the scientific, technical and socioeconomic interests go hand in hand with the development of a new type of municipal government that integrates these interests in spatial plans. This means, according to Van der Woud, a departure from the traditional way of planning, from private and very regional interests, to planning on a national level and thus on a much larger scale.

The second reason why Van der Woud's investigation is important to this research is connected to this and concerns the opening of the cities towards the landscape in the nineteenth century. Once the fortifications are no longer required for military purposes, the city landscape, the city ramparts and moats are redesigned as public space.[169] When redesigning the city's borders, the ramparts cannot simply be allowed to fall into the moat whence the soil has come, since the moat has an important function in the water and traffic system of the city. There is a demand and a need for an urban plan.[170]

The third example of the powerful connection between water management and urbanism are the new villages in the new polders. New polders are the ideal places for new technology – such as the steam engine. 'The dwellings on the new land, ordered in a united ring, inhabited by hard-working independent people, guarded by the hypermodern steam engine',

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166 Van der Woud 1987, 16
167 Van der Woud 1987, 260-262
168 Van der Woud 1987, 81
169 Van der Woud 1987, 302-304
170 Van der Woud 1987, 335

starting in the 1840s, are, according to Van der Woud, the beginning of the *maakbaarheid* principle.[171]

Van der Woud's analysis offers the reason for this investigation to take water management on the larger scale as a *conditio sine qua non* and focus on water management on a smaller scale. Also, it shows how in the nineteenth century the connection between water management and the spatial plan becomes even more important and crucial in the spatial order.

The last example is connecting to the second important framework that Van der Woud offers to this research, the *maakbaarheid* principle (the principle that everything can be manmade) and its technocratic development. Besides the conclusion that continuation and changes in the spatial order in the Netherlands are a mainstream issue in water management,[172] the theory and appliance of military and civil engineering are also interwoven with water management and therefore with urbanism. These determine the character of the plan in technical preparations and planning.[173]

The City Architect who, up to the end of the nineteenth century, has had a cultural mission, becomes a full-blooded technician in the function of director of public works at the beginning of the twentieth century.[174] The fact that technicians become part of governmental structures enhanced the idea of efficiency, *maakbaarheid* and the technocratic approach towards spatial planning. In the nineteenth century the state government plays an integrating role in spatial plans involving large-scale projects on which engineers are working, such as provisions for trains and channels. At the beginning of the twentieth century engineers develop planning into a technical discipline and the activities of engineers and government becomes homogenous.[175]

The third reason that Van der Woud's book is important to this investigation is his definition of urbanism. Urbanism, in Dutch *stedebouw*, is the design of human settlement. Urban engineering, in Dutch *stedebouwkunde*, is the profession that determines the relationship between the spatial design of the city and its functioning and considers how to put this into practice.[176] According to Van der Woud, as long ago as 1913[177] W.B. Petri shows in his publication that Dutch cities have no natural growth but react to natural circumstances, physical geography, landownership and land use, and government involvement.[178] After a new municipal law is passed in 1851, urban engineering becomes a method for the municipality to gain control of society and to break with the traditional structures of private involvement.[179]

Van der Woud separates urban engineering from urban art, *stedebouwkunst,* which is recognizable in eighteenth-century France and England in projects such as Place de la Concorde 1753-1775 and the Royal Crescent in Bath of 1767-1776. In France and England, urban art is continued

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[171] Van der Woud 1987, 262-263
[172] Van der Woud 1987, 453
[173] Van der Woud 1987, 480
[174] Van der Woud 1987, 377
[175] Van der Woud 1987, 302-304
[176] Van der Woud 1987, 485
[177] Petri 1913
[178] Van der Woud 1987, 426
[179] Van der Woud 1987, 429

in the nineteenth century in the Rue Rivoli and Regent Street.[180] According to Van der Woud, urban art, the impressive architectonic manipulation of public space, has by-passed the Netherlands due to the lack of demand by those who have the capacity to fund such development, the lack of landownership, the fact that the government has no tradition of displaying its status in urban constructions (although it does do so in civil works); in short, the lack of an architectural culture. Moreover, in the middle of the nineteenth century urban art is made subordinate to urban engineering.[181] Van der Woud illustrates this with the *Waterproject* (object of study in this chapter), which is an example of treating the disease rather than trying to prevent the patient from getting sick. Halfway through the nineteenth century there is an important change, the science of illness becomes the science of health.[182] Van der Woud states that this also changed urbanism from a treating discipline into aiming at prevention and concludes that at the end of the century urbanism falls back on the Greek principles of *Kalos* (beauty), *Kai* (goodness) and *Agathus* (efficiency [*doeltreffendheid*]).[183]

This approach to defining the different ways of considering the profession and the varied influences affecting it is an example and a starting point upon which this investigation seeks to elaborate.

Military and Civil Engineers

At the end of the eighteenth century there is a heterogeneous group of engineers specialized in water systems. There is no formal organization on a national level but there is an informal, fragmented civil service represented by the river inspectors in the Holland province.[184] During the French occupation (1795-1813) the French bureaucratic and centrally organized governmental structures are superimposed on the Dutch administration. *Le Corps des Ponts et Chaussées* (1716) and *Ecole des pont en Chaussées* (1747) are models of the organization and schooling of engineers. In France these institutions train expert engineers that are much respected in society. National leaders are often engineers.[185]

In the nineteenth century there are engineers working at the Water Boards who lose their autonomy because of the introduction of French bureaucracy. During the Republic water management is a decentralized activity, where necessary water is controlled by the locals, as they wish. After 1814, water management becomes of national importance and Water Boards are placed at the governmental height of the provinces. This special position is made solid in the constitution of Thorbecke in 1848. The division of tasks and responsibilities have hardly changed to this day.[186]

Engineers in the monarchy of the Netherlands (since 1814) receive a military education at the Royal Military Academy (started 1805) or a civil

[180] Van der Woud 1987, 434
[181] Van der Woud 1987, 436
[182] Van der Woud 1987, 446
[183] Van der Woud 1987, 412
[184] Lintsen 1980, 58
[185] Lintsen 1980, 58; Freiherrn von Weber 1887
[186] Brainich von Brainich-Felth 1993, 107-112

education at the Royal Academy in Delft (started 1842). The General Theoretical and Practical School for Artillery, Military Engineering, and Hydraulic Engineering, a school for leading military and civil functions, is founded in 1805 in Amersfoort. In 1814 the Artillery and Military Engineering School in Delft is founded. This school moves to Breda in 1827 and is renamed the Royal Military Academy in 1829. The privatization of the school for civil technology in Delft means that civil engineering can be studied there from 1842. Four courses are offered, including one for state water management, state mining and other governmental projects and one for non-governmental issues like mechanical engineering, water constructions, mining architecture and trade (ship building). The director, J.A. Keurenaer, clashes with the students in 1864 about the military approach. The school is consequently reorganized into the Polytechnic School. From then on, the courses are industrial engineering, mining, civil engineering, architecture, shipping and mechanical engineering.[187]

Besides their formal education engineers organize themselves in the Royal Engineers Society, KIVI, (1847) and the Society of Civil Engineers (1853).[188] General water management is the prime interest of the engineer because it is considered of national importance. Theory and use of technology are closely interwoven with the Ministry of Transport and Water Management and civil engineering. Both disciplines are focused on technical planning according to an established pattern, with the difference being that the military way of thinking has always been strategic, while civil engineering is more about tactics.[189] The many large-scale projects in the nineteenth century (railway, pumping lakes, and channels) cause engineers, who are mostly from the working class, to come into contact with higher social classes. The prestige of these projects and the engineers' expertise in realizing them lift their social status.[190]

Between 1846 and 1886, 561 civil engineers graduate; after 1881 there is an increase to 20 to 30 graduates per year, compared to 0 to 20 per year previously. The motivation for choosing civil engineering is usually social commitment. The construction of the railway is a large-scale project that requires many engineers and as a project has a high social status. Additionally, the education of civil engineers opens doors to many professions, but most men who study engineering are into math and construction. In 1887 an engineer is supposed to have a wide scope, be good in analyses of costs and profits and economically oriented. He is the connection between capital and society in industrialization and influences economic developments.[191]

Two articles in *De Ingenieur* illustrate the position of the engineer in society, or how the journal sees it. The first, written in 1887, sees the engineer in the front line of the fight for modernization, proving that the powers of nature can be controlled. Engineers carry a large responsibility, but are not appreciated for it. The articles describe how the fight for appreciation is difficult since the profession is so young and does not have a

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[187] Lintsen 1980, 151
[188] Lintsen 1980, 39-58
[189] Van der Woud 1987, 480
[190] Lintsen 1980, 125
[191] *De Ingenieur* 2 (1887), 65-66

solid position in society.[192] The second article, written two years later, is about a visit of the KIVI to the *Société des Ingénieurs*: ‘That is the meaning of these visits, to ensure that we, as children of one spirit, get connected, so that we can make the nineteenth century a time of peaceful triumph of technical science. Believe me, signed, J. de Koning.’[193]

Surveyors and Cartography

Modern cartography arrives on the scene in the nineteenth century, and land registries are set up in the cities, important for the payment of taxes. In 1816 inspector Temmink starts with the setting up of the land registries; the information is to be captured lot by lot and it takes till 1830 to have the measurements taken nationally.[194] Next to the land registries, in 1822 a commission is formed to investigate the production of a topographical map, important for military purposes, for scientific research, etcetera. General Kraijenhoff starts on the topographical map in 1841, using the triangulation method of measurement. The Netherlands is shown in maps on a scale 1:25.000. The reproduction is done in lithography on a scale of 1:50.000. The first part is published in 1850; the final part in 1863.[195]

In 1848 the Constitution of Thorbecke (1848) is proclaimed, which is still the basis of the Netherlands’ present democratic constitutional state. This law rescinds the centuries-old hierarchy of town and countryside. In 1851 the Local Government Act and the Land Clauses Act are adopted, enabling the government to expropriate land in the public interest. Regulated and uniform measurements, medical surveys, civil registration statistics, ordinances and planning – all represent the establishment of strategies, the development of control over the city.[196]

Despite the excellent quality of Kraijenhoff’s topographical maps, they do not visualize the water system, and in particular the polder system, well enough to enable the planning of major water works. The conditions of a terrain and the drainage system especially are complex to discover and draw on a map. A. van Egmond proposes in the meeting of the KIVI on 11 June 1863 to introduce a coloured map of the water system that shows:

1) The borders of the Water Boards or areas with a shared point of discharge;
2) Points of discharge and the levels of the water in relation to Amsterdam Level;
3) Polders and the summer level in relation to the medium level of the outlet drainage canal or river on to which they discharge;
4) Natural waters (rivers, streams, etcetera) and their water levels.

Minister Thorbecke decides to follow the advice of the board of the KIVI, and

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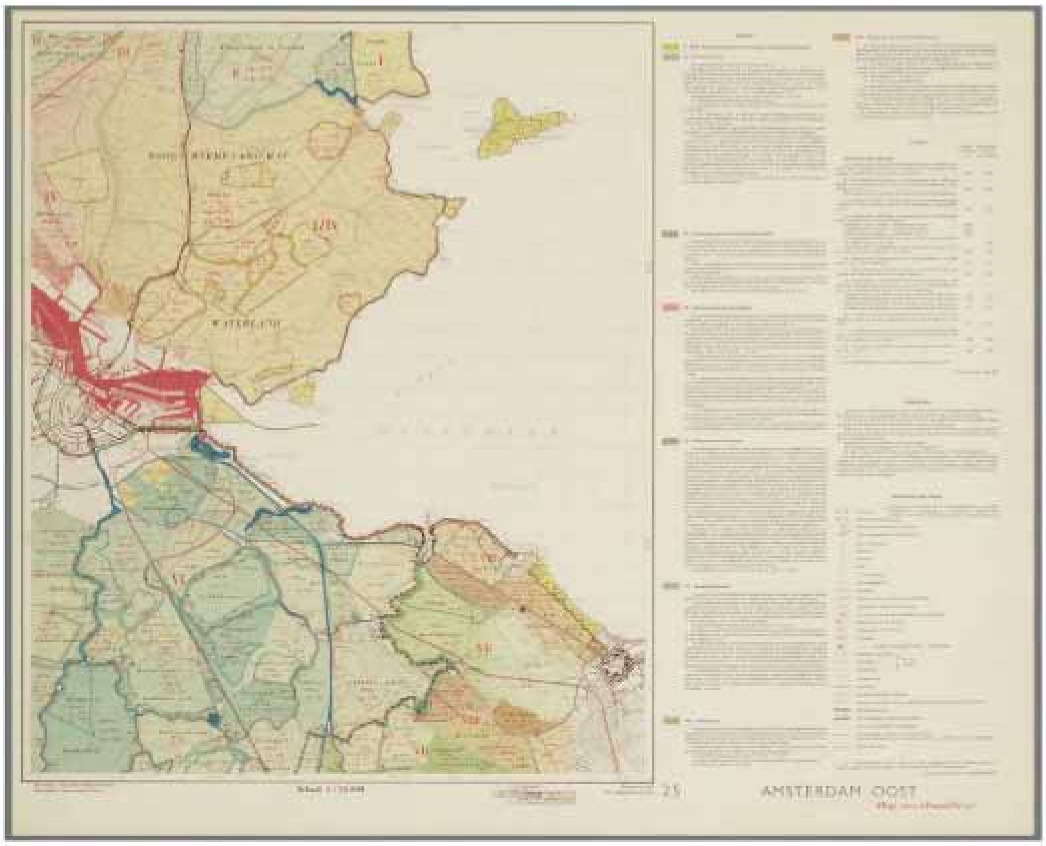
[192] *De Ingenieur* 2 (1887), 65-66
[193] *De Ingenieur* (1889), 321-325. Original Dutch text: *Dat is de beteekenis van de bijeenkomsten als die wij bijwoonden, dat wij, ieder in het bizonder om waarde latende, een gemeenschappelijken band slingeren om de kinderen van éénen geest, om hen, die zich, als wij ingenieurs, tot taak stellen de 19e eeuw te doen zijn tot een tijdperk van den vreedzamen triomf der technische wetenschap. Geloof mij, J. de Koning.*
[194] Van der Woud 1987, 36-37
[195] Van der Woud 1987, 34-36
[196] De Graaf et al. 1982, 98-100

gives the assignment to inspector F.W. Conrad and his topographical office. The first maps of Amsterdam are finished in 1865. The base is the topographical map of Kraijenhoff on which the polders, all the water works and the constructions are shown in colour. The maps are very well received, and the production of 183 pages is done by 33 engineers.[197] The '*Waterstaatskaart*' is unique for the Netherlands; no other country has a systematic series of maps showing the drainage of the whole country.[198]



Picture 4.3 *Waterstaatskaart* shows the different polders in different colours and next to the map all necessary details are noted. This map is from 1950 but the layout has not changed much since 1865.
Source: Rijkswaterstaat

[197] *De Ingenieur* 35 (1891), 313
[198] Van der Kleij 1965, Van der Linden 1973 and Blauw 2003

Urban Engineering

As of 1864, The Royal Academy in Delft offers 'architecture' as a specialization of the department of Road and Civil Engineering, so city architects are usually military engineers.[199] The first issues on the scale of urban design are the introduction of the railway (1837) and the hygiene concerns of cities (for instance water and housing).[200] The project of city architects in the growing cities of the nineteenth century is to provide a spatial organization that is characterized by the separation of conflicting functions and the bundling of functions that belong together.[201] Military engineers are trained to find the most efficient and best organized way to make use of the available space. The transformation of nineteenth century cities is characterized by breaking through and breaking down, filling and cleaning up: the city as a machine or a utilitarian work of art.[202]

Thus urban design is not yet a separate profession but part of architecture, surveying and civil or military engineering. Through professionalized technicians, urban design increasingly obtains a more technical instead of an administrative basis. Maintenance and management are more important than representation of the city design. The ideas about urban design are of secondary importance, incorporated into urban engineering, and decline into a technical profession within the municipal Department of Public Works.[203]

After the completion of the *Grachtengordel* and partially due to a period of ample urban development (1700-1850), no further large-scale city expansions in the Republic are realized. The first planned expansion of Rotterdam after 1850 manages to reach the conceptual calibre of the Ideal City by Simone Stevin and the *Grachtengordel*. City Architect and military engineer W.N. Rose (1801-1877) designs an urban water system independent of the polder water system, referred to as the *Waterproject*, assisted by landscape architects J.D. Zocher and L.P. Zocher. This project is described in the next paragraph.

Amsterdam, too, is finally able to make the leap across the encircling canal (which had formed the urban boundary since the seventeenth century), but the expansions do not equal the conceptual calibre of Rotterdam's *Waterproject*. In the nineteenth century's liberal political climate, the city council leaves the expansion of Amsterdam largely to the private sector. At first, even the building-site preparation, raising the ground 4 m with sand, is left in the hands of private developers. Scattered development like the complex of 68 labourers' dwellings along the Zuider Zaagmolenpad is the result. In addition, this project and those to follow it make use of the existing polder structure, which is the ownership structure, as a master plan. This culminates, at the end of the nineteenth century, in the district called De Pijp (meaning long small ditches), which lacks the elegant structure and systematic design of earlier expansions. The quality of the houses

[199] Lintsen 1994a, 201
[200] Meyer no date, 9
[201] Van der Woud 1987, 346
[202] De Graaf et al. 1982, 98
[203] De Graaf et al. 1982, 90

themselves also leaves something to be desired – some houses even collapse during construction. The phenomenon is referred to as 'jeny building' (*revolutie bouw*). The result is a ring of poorly built working-class neighbourhoods (with sealed surfaces), which due to their small scale cause problems with the water. Between these partial raisings the water is stationary, carrying the risk of malaria.[204] This risk leads to new powers of the municipal Authority to expropriate land in order to develop it in larger pieces. The municipality raises the land up to the level of 0.20 cm +MSL and then sells it again.[205]

Willem Nicolaas Rose

Willem Nicolaas Rose's (1801-1877) family owns a brick and tile work factory just outside Utrecht. After attending a French private school in Arnhem he is trained as a military engineer at the Officers' Academy in Delft and spends 16 years (1822-1838) in the army. During this period in the garrison he does some teaching and uses his time for private study into the science of building and architecture. Just before changing his career in 1838 to teaching at the Royal Military Academy in Breda, his plans change. The Rotterdam Authorities, temporarily without a town architect, approach him to design a new municipal hospital on the Coolsingel Boulevard. Probably through the intervention of his influential father-in-law, who is on close terms with the Burgomaster, he is appointed City Architect to Rotterdam. Because his task is so complex and extensive, instead of being an architect he is a technician and manager of a government service. He pretty much operates independently of the city council.

Rose is an excellent example of an urban engineer because he has technical capabilities and an urban vision. This is illustrated by the fact that he uses the steam engine to control the water and lower the groundwater table as a means of building-site preparation (the technology of urban design) and at the same time tries to realize necessary public space for green structures and a residential environment for more wealthy citizens (the social and visual aspects of urban design). Van Ravesteyn writes:

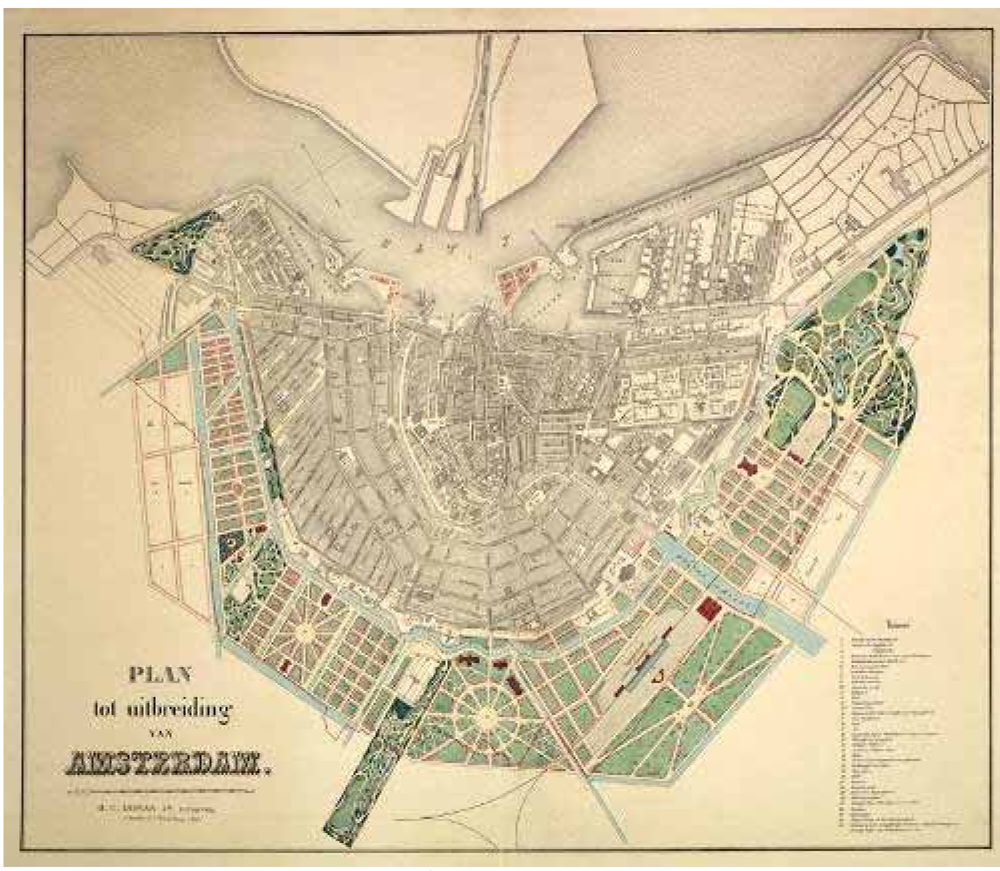
> The military officer Rose repeats what the old city builders did before him: outside the city moats he made new waterways, the excavated mud was used to make the dike. But what his predecessors did for military reasons, this former military man did to achieve better hygiene and to enhance the quality of living in the city.

The water demands a systematic expansion, which is one reason for city engineer J.G. van Niftrik (1833-1910) to draw an expansion plan as early as 1866. The son of a dike scout and at 19 years old already working for the

[204] Segeren and Hengeveld 1984, 26; Onderzoeks Instituut voor de Gebouwde Omgeving 1974
[205] Segeren and Hengeveld 1984, 27

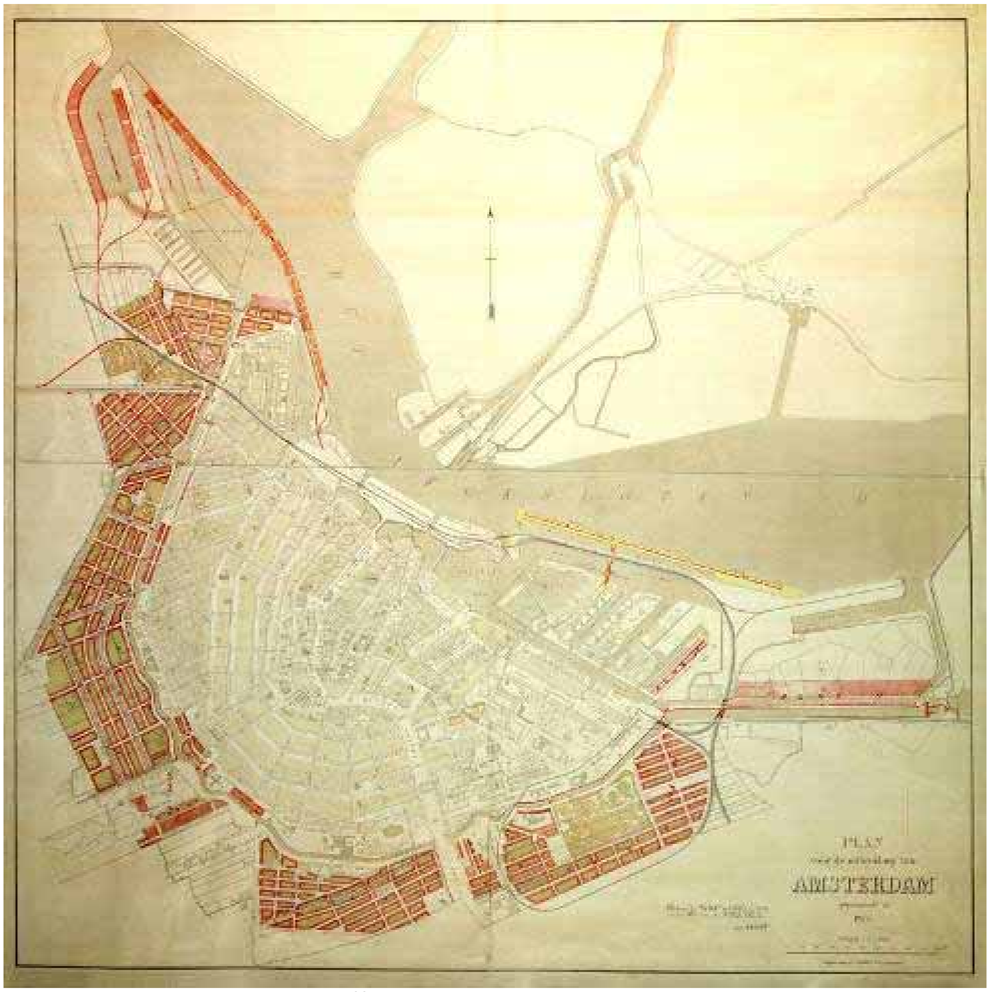
great water state engineer F.W. Conrad, he plans a ring of new neighbourhoods around the existing city, separated by parks in the English landscape style. The plan has a formal structure with straight streets, star-shaped squares and rectangular building blocks with continuous façades and much green. The design is oriented more towards architectural impression than the connection between the new neighbourhoods and the existing city.[206]

The unfavourable land parcelling is one of the main reasons for replacing this plan in 1875 by a pragmatic expansion plan based on the most lucrative land parcelling, produced by the director of Public Works J. Kalff. This design actually simply follows the polder land division again. This expansion plan produces new neighbourhoods such as the Staatsliedenbuurt, the Kinkerbuurt and the Dapperbuurt, packed with large numbers of inexpensive dwellings.[207] These poor residential building practices, in particular, lead to the 1901 Housing Act. The obligation of towns with more than 25,000 residents to draw up an expansion plan prompts consideration of larger structures in the city. Unfortunately, this is not the case for the water structure, in which interest is waning because of its loss of function.



Picture 4.4 Expansion plan by J.G. van Niftrik 1866
Source Municipal Archive Amsterdam - Collectie KOk, nr 501

[206] Emeis 1983 and Dienst der Publieke Werken 1975, 67
[207] Hogenes 1985, 9-10



Picture 4.5 Expansion plan by Kalff 1875-1876
Source: Municipal Archive Amsterdam

At the end of the nineteenth century canals called *singels* are used in Arnhem, Haarlem and Utrecht to embellish the city, and new civil administrators gladly call attention to their positions by such projects. The fortification walls lose their military function due to advances in weapon technology and the abundance of the defence system. The Fortification Act of 1874 allows the demolition of walls and fortifications and crowded historical cities can finally expand. Here again, the scale enlargement of the cities, like when stepping of the dry core, asks for a plan. The challenge of redesigning fortifications was picked up by garden architects. Thanks to the popularity of the landscape style, which has relatively low maintenance costs, fortifications are usually changed into parks with pedestrian paths, giving the towns public space with allure.[208]

[208] Meyer no date, 9

Building-Site Preparation

The ability to build cities on wet and soft soil is dependent on seven fields of knowledge, which have all developed from small beginnings in the previous time Phase. When considering the history of building-site preparation these areas need to be studied. The first, engine power, is the basis for all and is important for the movement of soil and water, the building and production industry. It is the main force behind the Industrial Revolutions. The second is general water management, which takes into account larger water systems like rivers, lakes and the sea. The third is the science of soil mechanics, which studies the characteristics of soil to determine its load-bearing capacity, compressibility, permeability, moisture capacity, etcetera. Parallel to soil mechanics is the fourth field of soil improvement, which combines soil mechanics with engine power and the method of building-site preparation. The second parallel to soil mechanics and the fifth field of knowledge is hydrogeology. It is the branch of the earth sciences that deals with the flow of water through aquifers and other shallow porous media. The sixth field is pile foundations and the seventh the field of drainage systems, including sewer systems.

As some of these fields are not widely developed in the nineteenth century there is no point in going into them in depth in this chapter. These are soil improvement, hydrogeology, pile foundation and drainage systems, which will have individual attention paid to them in chapter five.

An important step forward in hydrogeology is the publication of Darcy's Law in 1856 with its linear relation between velocity and hydraulic gradient, by Henri Philibert Gaspart Darcy (1803-1858).[209] It describes the flow of a fluid through a porous medium in a very theoretical way. In practice, engineers still have no idea of how groundwater flows really behave. Only knowledge by experience and what the eye can see is available.

Soil improvement before 1890 is done by removing the top layer so that the construction pit is deeper than the groundwater table. The development of pile foundations starts at the end of the nineteenth century when industrialization takes over this line of business and engines (steam 1842-1950, electric 1893-1960, oil 1926-today) are built to construct a foundation faster and more cheaply. The application of piles, however, is still the same today, apart from the current use of concrete piles and *in situ* construction.

The first mention of the term 'drain' (in Dutch) is in 1850 in a publication by R.A.C. Steinmetz *Over de drainage, waterafvoer door buizen onder den grond* (about drainage, water discharge through pipes underground). Considering his references the term is borrowed from English (and not French as other sources claim), supported by the development of drains in England.[210] J.M.J. Leclerc's *Traité de drainage Bruxelles* is published in 1853, the second edition in 1857.[211] The first pumping well is used for the theatre in Oldenburg in 1870. After 1900 this technique is employed on a

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209 Biswas, 1970
210 Aanvulling op het woordenboek der Nederlandsche Taal 2002
211 *De Ingenieur* (1886), 373; Also interesting publication about drainage in England is Darby 1956, The Draining of the Fens.

larger scale and it becomes commonly used after the Second World War.[212] More about these four fields of knowledge can be found in the following chapter.

I Engine Power

In 1887 *De Ingenieur* publishes an article about polder boys and their wheelbarrows.

> Our ancestors achieved miracles with polder boys and their wheelbarrows. The time that they were the main motors behind great works is not even that far behind us. Today excavators, elevators and sand machines are the forces in great works and manual labour has been replaced by steam-driven machines, but even now the polder boy cannot be missed. He remains essential for smaller works. Those who studied the polder people will have gotten to know them as muscled, fierce, lively people; indifferent to comfort, favouring a good meal; rough in manner, honest, illiterate but with common sense, aversive to bother, adoring freedom, critical towards formal rules but humble towards strange rules and customs coming from the forced demands of cooperation and community.

The article describes how these polder boys are significant in building great works and how machine power has taken over their work, how much faster and cheaper work can be done due to machine power.[213]

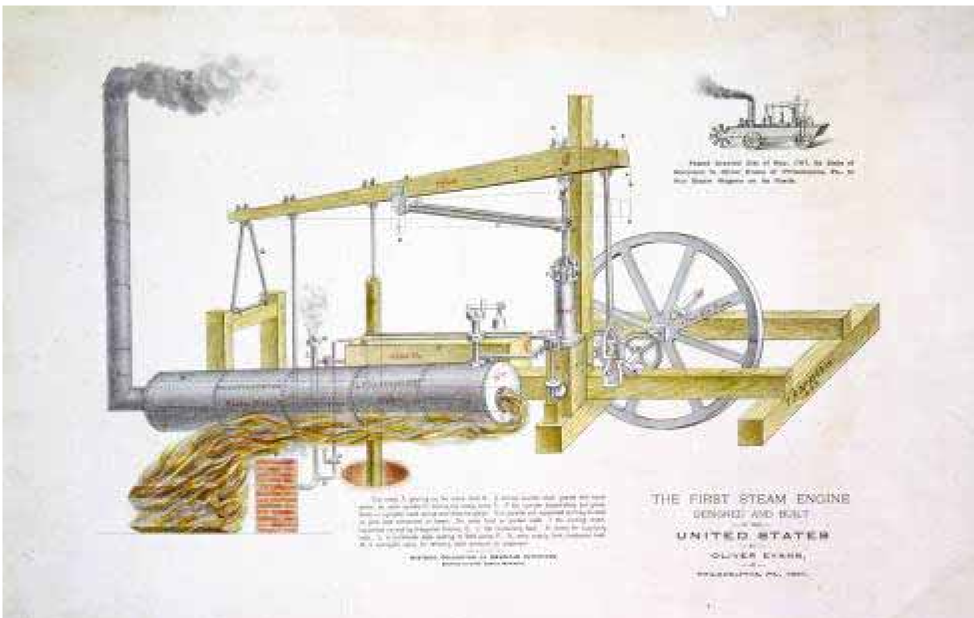
For the development of knowledge great projects are necessary. The main civil engineering projects of the nineteenth century are building channels and draining the Haarlemmermeer (1848-1852). The first great draining project with the use of (experimental) steam engines (and 30 windmills) is the Zuidplaspolder (1836-1839). After Thomas Newcomen designs the first practical steam engine (in 1705!), James Watt builds the first workable steam engine (1765). It signifies an increase of scale because more water can be pumped away.

The first attempt to install a steam engine – next to the east city gate of Rotterdam – is made by watchmaker Steven Hoogendijk in the mid-eighteenth century.[214] He is convinced this 'fire machine' – which he heard of through the work of professor Desaguliers in London (1751) – will be a better asset in the fight against the 'water wolf' than the windmill. In 1757 he convinces the city board of this necessity and they send city mill man Maarten Waltman to London to investigate. His negative report, especially about the pressure tube being too tight, makes the city board reluctant to adopt the plan. Hoogendijk, upset at the ignorance of the mill man, founds *Het bataafs genootschap der proefondervindelijke wijsbegeerte* (The Batavian society of experimental learning) on 17 August 1769 with the credo *Certos feret experientia fructus* (experience will give reliable products).[215] He appoints his friends J.D. Huichelbos van Liender and Dr L. Bicher as the presidents of this society. The first working steam engine in the Netherlands

[212] *De Ingenieur* 44 (1938), BW no. 18, B211
[213] Neyt 1887, 261
[214] Van der Pols 1977, 185
[215] Anonymous 1922, IX

is installed in 1787 to drain the Blijdorp polder in Rotterdam.

In the archive of the society there is an article, ‘The engine for raising water by fire’ (1725), which Hoogendijk obviously studied very well. The city board approves a report in 1774 that gives Huichelbos van Liender and his associates permission to build a ‘fire machine’ in the tower next to the east gate of Rotterdam, in order to pump the water from the city canals into the Schielands Hoogen Boezem (the main outlet waterway). This Newcomen’s machine is assembled by Jabez Carter Hornblower on 9 March 1776.[216] The tests with the machine go wrong, however, because Hoogendijk is stubborn and uses a wooden pump, rather than following Hornblower’s advice to install an iron pump.[217]

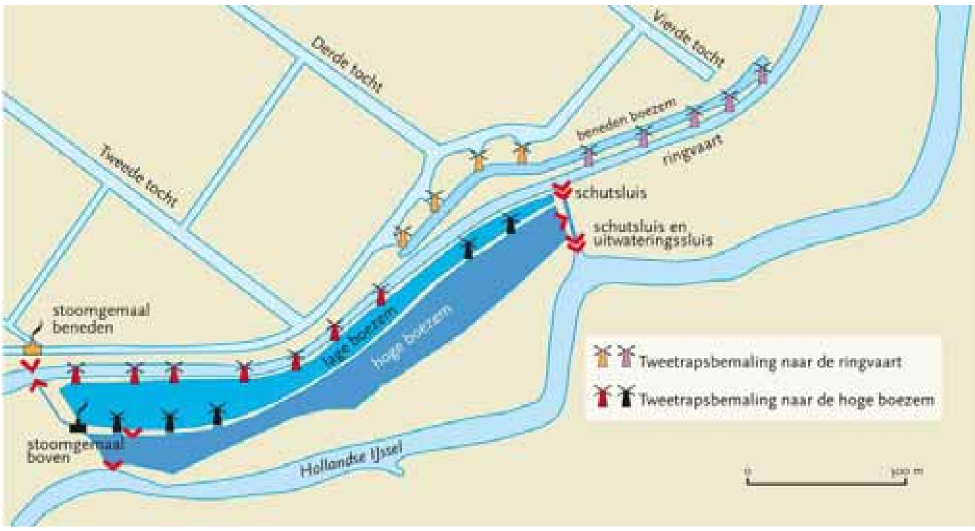


Picture 4.6 First Steamengine by Oliver Evans 1787
Source: Library of Congress, USA

In 1784 Bicker and Huichelbos van Liender convince Hoogendijk (who is 87) to put up the finances (fl. 25,000) for a new steam engine they want to build in the Blijdorp polder outside Rotterdam. Lambertus Bicker (1732-1801) publishes an article in 1772 on the virtues of the steam engine versus the windmill: ‘De groote voordelen aangetoond, welken ons land genieten zou, indien men vuur-machines in plaats van watermolens zou gebruiken’ (Proof of the great advantages that would benefit our country if fire machines were used instead of windmills).[218] The machine is ordered from Bouton & Watt because Huichelbos van Liender contacted Watt after the former failed attempt. The construction of the fire machine garners a lot of complaints from local farmers who are afraid that the machine will disturb their cows. Mechanic Macolin Logan of Boulton & Watt starts the engine on 8 September 1787. Present at this event is the very content Hoogendijk, who dies a few months later at the age of 90.

[216] Bataafs genootschap 1880
[217] Van der Ham 2004, 121-123
[218] Lintsen 1994b, 134

The second successful project takes place in 1793, with a steam engine that pumps dry the Meydrecht Lake, also made by Boulton & Watt. The Zuidplaspolder is reclaimed between 1836 and 1839, using 30 windmills and two steam engines. The water from the lake is pumped in four steps by two sets of windmills to the IJssel River. The steam engines can also be used is the case of calamity, in a two-step system.[219] In 1807 there are doubts about whether or not it is possible administratively, financially and technically to reclaim the Zuidplas. In 1837 it is proven that it can be! This is a great boost for the self-confidence of public works.[220]



Picture 4.7 Drainage system of the Zuidplaspolder, using 30 mills and the two steam engines are for emergencies. Yellow and purple mill are pumping to the Ringvaart, the red and black mills are pumping to the *hoge boezem*.
Source: Van der Ham 2004

High costs and problems that are difficult to solve because of the lack of mechanics mean that it is not until 1849 that another large project with steam engines is started: the Haarlemmermeer. After that the use of steam engines becomes common and windmills fall increasingly out of fashion. In 1937 there are still a lot of steam engines in use, including some recently built like Lely Centrale (1931).[221]

Steam dredge mills are used extensively in England in the mid-nineteenth century. Following the abolition of the tax on coal, the use of steam engines becomes cheaper. Efficiency improvements in the 1860s make the steam engine even more attractive. The first dredger is bought by the municipality of Amsterdam in 1861. When mud needs to be transported over a long distance, floating wooden pipes are used with leather connectors, bridging up to 300 m. Soil and water are mixed in a compartment with a centrifugal pump. This system is developed in 1867 by J. Burt and S.T. Freeman, respectively inspector and engineer of the English contractor Henry Lee & Son. The principle is improved by the Dutch at the end of the nineteenth century and used to spout up sand, which is why the machines

[219] Van der Ham 2004, 151-152
[220] Van der Woud 1987, 277
[221] Muller 1937

are known as Dutch Dredgers. Subsequently, the invention of the centrifugal pump in 1875 causes an explosive increase in the number of steam-driven pumping stations.[222]

After the mill, the steam engine forces the most significant changes in technology and marks the change to the Offensive Phase. The Industrial Revolution (mass production and steam-powered engines) overtakes the Netherlands much later than its neighbouring countries. It starts after 1850 (England 1760) and takes flight in the 1890s after the depression (1880s). More than 150 years after its actual invention, around 1850, the steam engine ends the era of the drainage windmill and the construction of high-pressure steam engines enables pumping and dredging on a large scale.

II General Water Management

From 1741 onwards the rivers cause the government concern. The Bureau of Water, the predecessor of the Department of Waterways and Public Works, is managed by Christiaan Brunings (1736-1805) during its first 30 years of existence, with on his left and right hand respectively Jan Blanken (1819-1824) and Adriaan Goudriaan (1822-1826); all three are leaders with a social recognition. In 1769 Brunings becomes commissioner inspector of the country's rivers and plays an important role in the negotiations between the King of Prussia and the regions of Holland and Gelderland regarding the distribution of Rhine water across the Waal, Lower Rhine and the IJssel. After 22 years of negotiations a treaty is signed in 1771, which signifies a first step towards international consultation about matters of water. Brunings is also involved in the improvements to the water defences along the Rhine.[223]

In 1815 the Ministry of Transport and Public Works is established and a year later the Body of Engineers of the Ministry of Transport, a department of the ministry, which is given the name Department of Waterways and Public Works in 1820. In 1821 the River Committee is set up as a subdivision.[224]

The engineers have a lot of work since the first monarch King William I – known as the 'Channel King' – commissions many channels during his reign in order to improve the Dutch economy: Willemsvaart (1819), Zuid-Willemsvaart (1822-1826), Noordhollands Kanaal (1824), Keulse Vaart (1824-1826), Kanaal van Gent naar Terneuzen (1825-1827), Kanaal door Voorne (1827), Dedemsvaart (1828 1840) and Griftkanaal (1829-1865).[225] Besides the economy also the technological development is helped with these commissions.

In the field of general water management theoretical models continue to be created; the use of Bernoulli instruments to measure the flow velocity of rivers makes it is possible to calculate how strong dikes and sluices need to be. In dike building the main transformation during this period is that from 1840 boulders are replaced by basalt. For sluices Jan Blanken Jz. (employed by the Ministry of Transport, Maritime Works and as a port inspector) develops 'fanned' sluices in 1808. These are now known as ordinary sluices.

[222] Lintsen 1994a, 244
[223] Van der Woud 1978, 51-52
[224] Van der Woud 1978, 55
[225] Van der Woud 1978, 115

Prior to this, different sluices are needed for each sailing direction, as the doors can not work against the force of the water.[226]

After 1850 work on the rivers is systemized under pressure of the danger of flooding. River traffic is not only disrupted by regular floods, but also by the drying up of the rivers (1857). From 1861 the Department of Waterways and Public Works has steam dredges at its disposal to keep rivers at a certain depth and in 1872 an independent Directorate of River Control is formed under the management of P. Caland. Also, to protect the hinterland, 100,000 hectares are reclaimed: Neuzenpolder (1816), Finsterwoldepolder (1819), Uithuizerpolder (1827), Waard and Groet (1844), Anna Paulownapolder (1845-1847) and Anna Jacoba and Kramerspolder (1847).[227]

Under pressure of flood danger various plans to close off the Zuiderzee follow each other: the Kloppenburg and Paddegon Plan (1848), engineer B.P.G. van Diggelen develops the Department of Waterways and Public Works Plan (1849), engineer J.A. Beyerinck (1866) and A. Huet (1862-1875 and 1870-1895). In 1886 the Zuiderzee Society is founded to study the feasibility of the plans. In October Cornelis Lely takes up his duties with the Society. In the following decades he devotes himself as Secretary of State for Transport to the execution of the plans.[228]

The reclamation of the Haarlemmermeer (1848-1852) strengthens the position of technicians in relation to the government. Civil engineers prove that they can produce the interventions desired by the government, and the developments follow fast. What they can do is indeed impressive: control rivers, drain lakes, reclaim land, build railways and dig channels.

In the Phase of the Offensive attitude towards the natural system, the new power is prosperous for general water management, not only because of industrialization, but even more so due to the systemization of knowledge. Good organization transforms knowledge by experience into systemized building knowledge in hydrology and hydraulics. The force of the machine, the build up of knowledge and the systemization of organization all lead to a coherent discipline in the following Phase.

III Soil Mechanics

The development of building-site preparation methods is largely based on soil mechanics, a science that matures in the twentieth century. In the Netherlands the first publication that considers Coulomb's work is an article by Brunings, the main actor in a former paragraph, in the *Verhandeling van het Bataafs Genootschap* (1803): 'Over zijdelingsche drukking der aarde en de hier naar te regelen afmetingen der muuren' (About the sideways pressure of soil and the structural design of walls). The article breathes of the Enlightenment because Brunings is convinced that the time has come when the distance between theory and practice is shrinking. This is due to the use of the same language and more understanding between the theory of observation and the practice of blind searching. Other Dutch scientists who contribute to the knowledge of soil mechanics are D. Mentz (1785-1847) and I.P. Delprat. The latter writes the 'bible' of soil mechanics for the Military

[226] Van der Woud 1978, 479
[227] Van der Woud 1978, 245
[228] Van der Woud 1978, 247

Academy in Breda (1837), about the pressure of soil on stone walls (in building fortifications).[229]

Coulomb's Law, used to calculate ground pressure, offers such a grasp of the matter, however, that the world of practice is not eager to learn more. Bruning's idea of closing the gap between theory and practice becomes even less realistic at the end of the nineteenth century. The gap is closed more than 100 years later by Terzaghi in 1927.[230]

What De Bélidor and Coulomb start in the previous period has more effect in England than in the Netherlands. William John Macquorn Rankine (1820-1872) publishes an article on the possible states of stress in soils in 1857 that studies the internal rubbing causing a range of acceptable tension areas, marked by an active and a passive condition. Coulomb develops a purely theoretical model considering the balance of soil mass. He gives each type of soil a certain rating in moisture dependent cohesion, and introduces a new soil-specific characteristic, the angle of internal friction ϕ, which measures the resistance of the soil type towards land sliding. When the cohesion between the soil particles is zero, the angle is the same as the angle of a natural gradient.[231]

The principles of the mechanics of continua, including statics and strength of materials, are also well known in the nineteenth century, due to the work of Isaac Newton (1643-1727), Augustin Louis Cauchy (1789-1857), Claude Louis Marie Henri Navier (1785-1836) and Joseph Boussinesq (1842-1929). Around 1850 systematic soil research starts with taking samples by drilling. The development of soil mechanics needs large projects, like the building of the railway system in 1839.[232] A union of all these fundamentals into a coherent discipline is not established in Phase of the Offensive attitude towards the natural system; the next Phase of accelerating powers is the triumphant period of soil mechanics.[233]

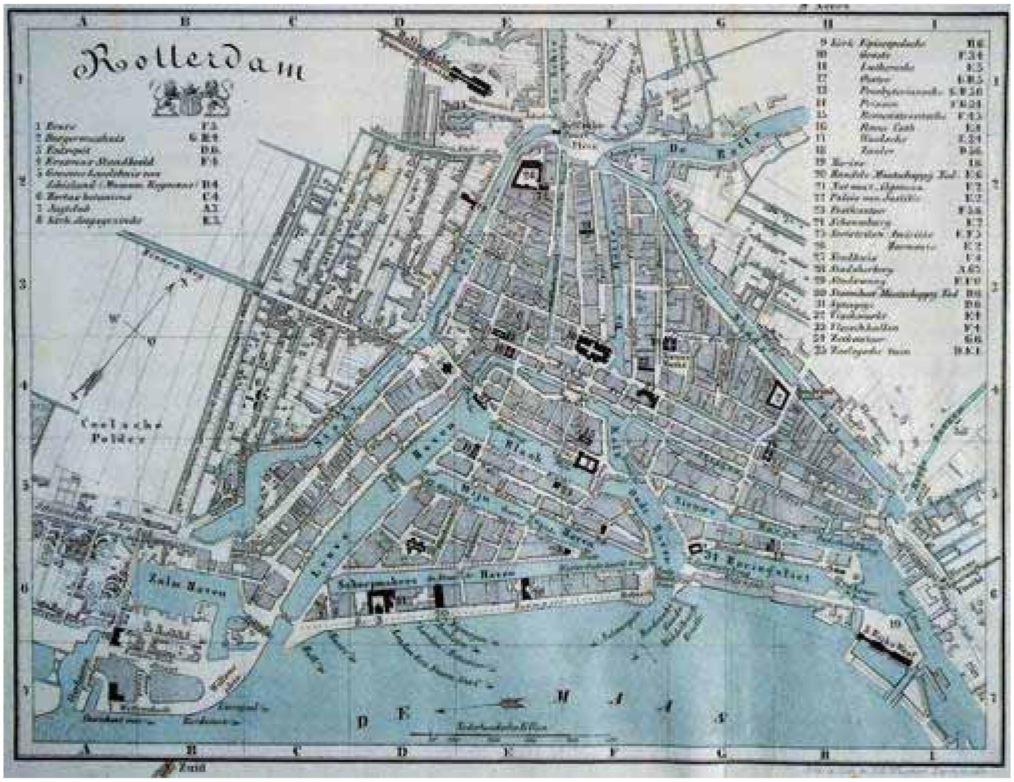
Building-Site Preparation

At the start of the nineteenth century the general practice of urban development in Dutch cities follows the lines of ownership structures: the polder allotment. This is the master plan used by private developers building for anonymous buyers. Municipalities prepare the sites, but the developers have to pay them for this. The most common way of preparing sites was the 'cunet' method: where the road or building is projected the soft soil is excavated and filled with sand. Lowering the groundwater table becomes an option with the arrival of the steam engine.

During the Phase of the Offensive attitude towards the natural system industrialization and the systemization of knowledge of hydrology and hydraulics start. The force of the machine, the build up of knowledge and the systemization of organization all lead to a coherent discipline in the following Phase in which building-site preparation takes flight.

[229] Lintsen 1994c, 163-164
[230] Verruit 2001, 7
[231] Verruit 2001, 196-204
[232] De Vet 1994, 5
[233] Verruijt 2001

Rotterdam Waterproject



Picture 4.8 Rotterdam in 1850 with the illegal buildings outside the city moats.
Source: Municipal Archive Rotterdam

After the completion of the *Grachtengordel* and partially due to a period of ample urban development (1700-1850), no further large-scale city expansions are realized in the Republic until the second half of the nineteenth century. This is the result of low economic conjuncture and the laws that stipulate that cities stay behind their fortifications. The few expansions that are made follow the pragmatic system of polder lots. The expansions of Leiden (1659) and Haarlem (1672-1690) show the pattern of the polder ditches being simply urbanized.[234] The first organized expansion of Rotterdam in the second half of the nineteenth century manages to reach the conceptual calibre of the *Grachtengordel*. Like Amsterdam, Rotterdam is built on peat and has a low ground level prone to flooding, as a result of which hydrological preconditions determine the urban design, as the *Waterproject* will show.

A significant difference between Amsterdam and Rotterdam is the fact that Rotterdam has no strict boundaries with regard to the ordering of land and water. Based on the connections of the canal system, with inlet sluices on the river and discharge sluices on the open water, Amsterdam has a system of permanent flushing its city water. In Rotterdam there is no distinction between city and polder water, all falls under the control of the water board of Schieland. Moats and city water have the same level as the

[234] See Burke 1956 and Taverne 1978

Rotte and therefore also serve as *boezem* of Schieland. In the eighteenth century this leads to complaints about very high water levels in the city, causing houses to flood, when the lakes in the hinterland are pumped full of water. By 1722 there are negotiations for an extra *boezem* between the hinterland and the city. In 1769 the city and the water board of Schieland come to an agreement and in 1775 the *boezem* is realized.[235]

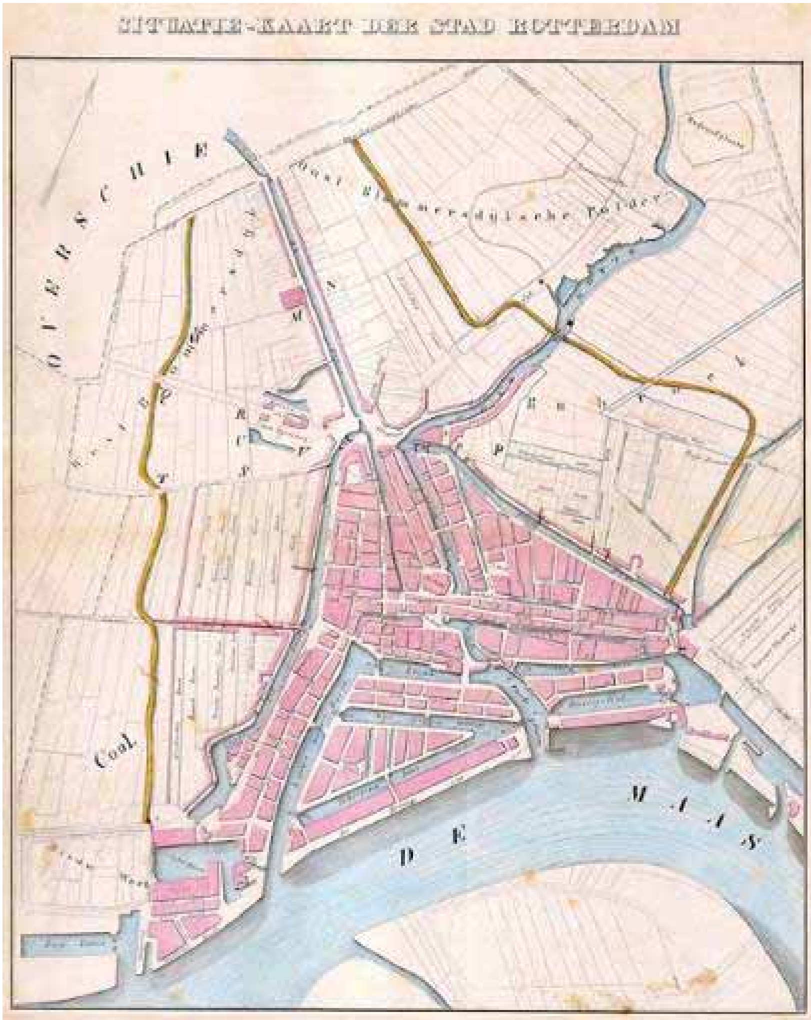
This is a solution for the flooding problem but not for the quality of the water. Schieland adjusts the inlet of water to the needs of agriculture, making it impossible for the municipality to clean the city waters. Yet this is of major importance, since the canals serve both as a drinking water facility and sewage system.

In 1719, Rotterdam prohibits throwing waste into city canals, but the pollution of the city waters continues to increase, resulting in a number of cholera epidemics in the nineteenth century.[236] Other regulations are: ordinances relating to buildings, the making of streets and quays, ordinances forbidding 'any crafts and works' in certain areas for the advancement of cleanliness, fire regulations, a law on property boundaries and related matters. Most houses have brick collecting wells or dung pits for faecal matter that are emptied regularly. The brick wells gradually become stacked and often leaky pits and much waste from houses and warehouses ends up in the town waters. The upshot is an almost complete shortage of water fit for drinking, even though the 1826 ordinance for the advancement of cleanliness points out another source of pollution, to wit, the pigs, goats 'or other damage-inducing livestock' that are kept in town.

The water in the old city triangle causes sanitary disasters and between 1848 and 1854 various measures are taken to remove the water from public space. However, the differences between the measures taken make the situation even worse. Some canals are filled in or covered; others replaced by a sewer, but most of them are not. The open water system is transformed into a non-system where open water and sewers alternate or terminate altogether. The quality of the open water dramatically worsens and its urban quality becomes zero.[237]

Besides the dirty state of the inner city, the polder outside the city suffers from an open sewer system. The dense old city is overcrowded and many poor townsfolk move to the polder areas just beyond the old town moats, the so-called Lanenkwartieren. There they live in miserable wooden hovels and start up modest businesses, filling up these wet areas without as much as one by-law being applied there. In 1412 Rotterdam forbids building within a distance of 1100 m outside the moats.[238] In 1618 and 1642 this rule is renewed and again in 1645, with the exception of five inns where people can eat and drink. These exceptions illustrate the fact that by then illegal development is taking place and that by legalizing formal public places certain activities can be prevented.[239]

[235] Van Ravesteyn 1935, 15
[236] Keur van den 19 april 1719 art 23
[237] Van Ravesteyn 1924, 92
[238] Van Ravesteyn 1935, 8
[239] Van Ravesteyn 1935, 10



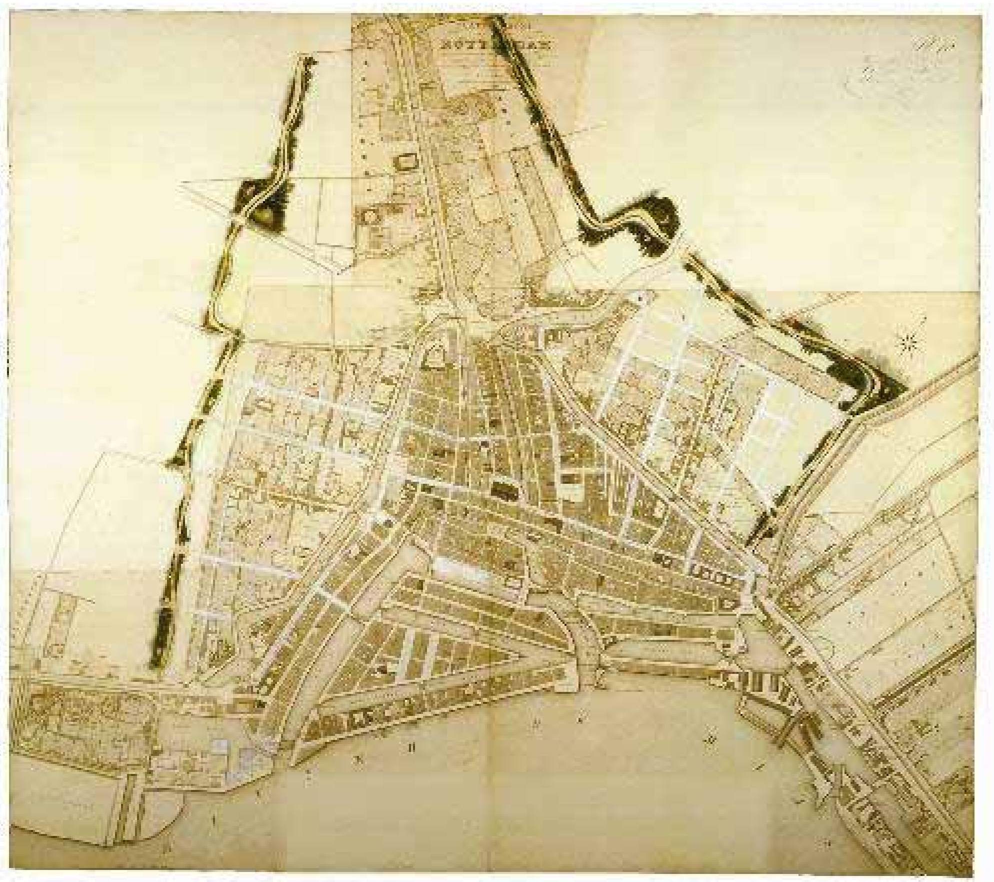
Picture 4.9 First *Waterproject* designed by Rose in 1841
Source: Municipal Archive Rotterdam

The ‘Plan van het Bestuur der Gemeente Rotterdam tot Verbetering en verversching met Maaswater der wateren van de zoogenaamde binnenstad van Rotterdam en de daartoe behoren de polder’ (Plan of the municipality to improve and refresh the inner city of Rotterdam and its surrounding polders with Maas water), describes how the dirty water in the inner city flows via ditches into the polders and creates thousands of cubic metres of damaging gasses. The houses there are usually not properly constructed; the water reaches the thresholds and water seeps through the wooden floors. This causes a lot of concern for the sanitary quality of these areas.[240] In the social sense also there is a gap between the city people and the poor people in the polder. During a discussion about the finances for a bridge over the Vest (the city moat) it is said that it would be better not to have a connection to that dirty and immoral area.[241]

[240] GAR, OSA, 4963-4966, stukken betreffende het Waterproject van W.N. Rose 1841-1863
[241] Van IJsselsteijn 1888b, 5

Waterproject 1841 and 1854

In 1841 the city council puts together a commission to investigate the sanitary circumstances in the city. Advisors to the committee are W.N. Rose, City Architect from 1839, and J.A. Scholten Hzn., surveyor of the Schieland Water Board. In 1842 Rose and Scholten present a plan that disconnects the urban water from the polder water system, they name it *Waterproject*.



Picture 4.10 *Waterproject* 1854 with the landscape design by the Zochers
Source: Municipal Archive Rotterdam

It takes 12 years to get the plan accepted (1854) because it is expensive and a decision concerning waste disposal had still not been reached. Also, the municipality has trouble convincing the Schieland Water Board of the fact that flushing the moats will help. The Board insists on sticking to its ordinances (of 15 February 1571) that the culverts can be opened only three times a week and never in the winter.[242]

Two cholera epidemics, in 1853 and 1854, speed up the decision-making process about the *Waterproject*.[243] Again, the city council installs a commission that concludes that the *Waterproject* is the best answer to the very bad quality of the inner city water. Rose and Scholten are asked to develop the plan of the two watercourses and leave out the expensive parts of the first plan (1841: several sluices, pumps and abattoirs). The renewed

[242] Van IJsselsteijn 1888b, 3
[243] Van IJsselsteijn 1888b, 5

Waterproject is accepted by the city council in 1854, albeit in a modified form and assisted by landscape architects J.D. Zocher and L.P. Zocher.

The plan serves four purposes: flushing the city water, lowering the groundwater level so that the city expansion can be built, building a city walk, and the development of a residential area for wealthy citizens.[244] The plan is a perfect example of how water management, the structure of ditches and dikes, determines the layout of urban expansions. The existing difference in ground water level is used in a practical way to direct the clean water of the Maas from the city ramparts (outlet water level) through culverts to the lower-level watercourses (polder water level) and then through two steam-driven pumping stations back into the Maas. The canal route, from dike to dike, has the same profile everywhere: on the outer side of the watercourse a dike with a road and footpath, the *singel* (a canal in a green structure without a stone quay).

Water System

Rose writes that the main aim of the *Waterproject* is to have flowing water in the city, with a forceful flush to remove all the dirt from the bottom of the waterways. This will allow plants to start to grow again and help clean the water.[245] Rotterdam has a quite extensive water network that consists of three parts: the water city, the inner city and the polders. Each part has a system adapted to the specific circumstances, and especially the ground level.

The water city is 2.60 to 3.60 m above R.P.,[246] the inner city is only 0.30 to 0.60 m above R.P. (the Maas water at high tide rises to 1.20 m above R.P., the dike along the Hoogstraat is crucial in that sense and shapes the city structure). Here no filth destroys the water quality because twice daily it is forcefully cleaned by the Maas water. The water system in the inner city is divided into three parts: the western part where the canals are in contact with the Schie, the eastern part where the water is connected to the Rotte and in-between Binnen Rotte and Delftsevaart, where water communicates with both Schie and Rotte. The Schieland Water Board therefore controls all the water in the inner city.

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[244] Hooimeijer and Kamphuis 2001
[245] Toelichting Rose opzoeken in klapper
[246] R.P. is Rotte Peil Which was 60 cm below NAP Nieuw Amsterdam's Peil of Mean Sea Level

Jan Arent Scholten

Rose's partner in crime is Jan Arent Scholten (1793-1876) who works as surveyor with the Schieland Water Board (Hoogheemraadschap van Schieland), and makes a major contribution to the design for the *Waterproject*. Scholten is brought up in Delft, where he studies 'mathematical and mechanical engineering sciences': sluice and windmill building, arithmetic and surveying, and the practice of civil engineering. After graduating he becomes the superintendent of the Public Works Engineering Corps, working under the celebrated inspector general Jan Blanken. In this capacity Scholten is responsible for, among other projects, the construction of flood gates for settlements such as Asperen. Later he works on the marine basin at Nieuwe Diep near Den Helder, and constructs a sluice, a steam engine and an inland harbour. From 1817 to 1863 he works as a surveyor with the Schieland Water Control Board, where he is responsible for every aspect of water management and civil-engineering projects. He designs sluices, mills and pumping stations and publishes frequently on the subject. Scholten is a member of the Rotterdam Public Health Commission. His enthusiasm for architecture can be deduced from, among other things, his membership of the Society for the Promotion of Architecture.

Scholten is responsible for the consequences on water management level when the city in water management terms is separated from the polder. He represents the interests of the Water Board and can therefore, with Rose, make a plan that satisfies both parties. Rose is responsible for the urban planning part of the plan, he confesses in 1842, when the first plan is rejected, that he as City Architect did not want to get into the field of water management and left that part of the plan to Scholten.

The ground level in the polders is 1.60 m below R.P. The low-lying polders also depend on the level of the boezems (Schie and Rotte) and the pumping stations (windmills) for their discharge. This double dependence makes the situation in the polders even worse than in the inner city, because at high tide the dirt sometimes flows into the houses as described above.[247]

The *Waterproject* aims at:

1) Cleaning the water in the city and polders;
2) Making the water in the inner city independent from the boezems of the Schieland Water Board;
3) Making the polders Rubroek, Cool, East and West Blommersdijk independent of the steam mills and windmills draining them;
4) Making new watercourses, *singels*, to compensate aim 3 and to make a graceful walk;

[247] GAR, OSA, 4963-4966, stukken betreffende het waterproject van W.N. Rose 1841-1863, Memorie van toelichting voor het waterproject.

5) Preparing for the urbanization of the *lanenkwartier* with streets, sewers, etcetera in the polders Rubroek, Cool, East and West Blommersdijk. This will demand a detailed plan in later stages but is important to take into account when realizing aims 1 to 4.

The interventions Rose and Scholten presented:

A) Close the connection of the waters in the inner city with the *boezems* (Schie and Rotte) of the Schieland Water Board;
B) Close the polders Rubroek, Cool, East and West Blommersdijk, as far as there are buildings, from the steam and windmills that pumped the polders;
C) Make two dike systems with watercourses on the inner city side, independent from each other, along the east and west side of the city, with different sewers and culverts to discharge the wastewater;
D) Build two steam-driven pumping stations, to create the necessary flow of the water from the Maas into the watercourses and back into the Maas.

The proposed interventions are worked out for the two areas: the eastern part of the inner city together with the polders Rubroek and East Blommersdijk, and the western side of the inner city together with the polders Cool and West Blommersdijk. See picture 4.11 for the explanation of the areas and the locations.

In the eastern part of the plan the inner city (24 ha) consists of 15 per cent open water (3,7 ha): Achterklooster, Kipsloot, Rubroekse Vest and Karnemelksehaven. To close this part off from the Rotte *boezem*, a sluice is built in the Rubroekse Vest (**f**), the Karnemelksehaven (1000 m^2) is filled in and a dam is built in the Botersloot (**f**). The water is flushed by letting in Maas water through a culvert under the East Gate (**a**); 570,000 m^3 every day. Discharge is effected by the sluice near Kouwenburgs Island, and a new steam pump at Rubroekse Vest (**h**). In the Rubroek polder a dike is constructed to separate the urbanized part of the polder (52 ha) from the rest. To lower the groundwater table it needs to be drained more than the original polder. The dike is planned 0.90 m above ground level with an accompanying watercourse with a capacity of 10 m^3(in section). This watercourse collects all the water from the polder and is pumped out by the steam pump at Rubroekse Vest. The water is led into the polder via five culverts (**c**), 125,000 m^3 every 24 hours. This is more than necessary considering that the ditches can hold 20,000 m^3 of water. To connect the watercourse in the Rubroek polder with the one in East Blommersdijk a culvert is placed under the Rotte (**g**), the *boezem* of the Water Board Schieland. In East Blommersdijk the same system as in Rubroek is built: a dike with a watercourse that separates 45 ha of the polder. From the Schie water is let into the system and through the culvert under the Rotte and the watercourse in Rubroek to the east pumping station.

The western part of the *Waterproject* includes the inner city (17 ha), of which almost a third is open water (5 ha): Spinhuiswater, Franschewater, Doelwater and Coolvest. The Coolvest is separated from the Schie by a sluice (**e**). The Franschewater and the Doelwater are separated from the

Delfteschevaart by culverts that can be closed. These culverts and sluices also supply fresh water to the inner city. Daily, 186,000 m^2 of water is let in through a culvert in the Schiedamschedijk (**b**) and transported to the Cool polder (47 ha) and West Blommersdijk (44 ha) which, like the eastern part, are supplied with a dike, watercourse and four culverts (**c**) that transport the water (30,000 m^2 per day) to the new steam-driven pumping station at Westzeedijk (**k**). Where the transport routes cross roads, dikes or other waterways, culverts are placed to make connections (**d**).[248]

The state head engineers of water F.W. Conrad and D.J. Storm Buysing evaluate the *Waterproject*. A few adjustments are suggested. In the polders (especially Rubroek and West Blommersdijk) all ditches need to be deeper, cleaner and properly connected with each other to make the water flow. They also emphasize the need to connect the two parts so that if one of the pumping stations fails, the other can take over. This is done at the Proveniers House, by connecting ditches and a culvert under the Schie (↔).

Although Conrad and Storm Buysing make only minor adjustments (adding or deleting culverts, adjustments to sluices, enlarging the capacity of the pumping station and raising the dike above R.P.), they regard the plan as very general, and in need of much detailing. Also, they suggest making a street layout in the polders to structure the urban development and have a more regulated water system at the same time. Conrad and Strom Buysing believe that in the practice of urban development, developers not building in an orderly fashion, houses scattered around forming narrow alleys, produce bad water circumstances.[249]

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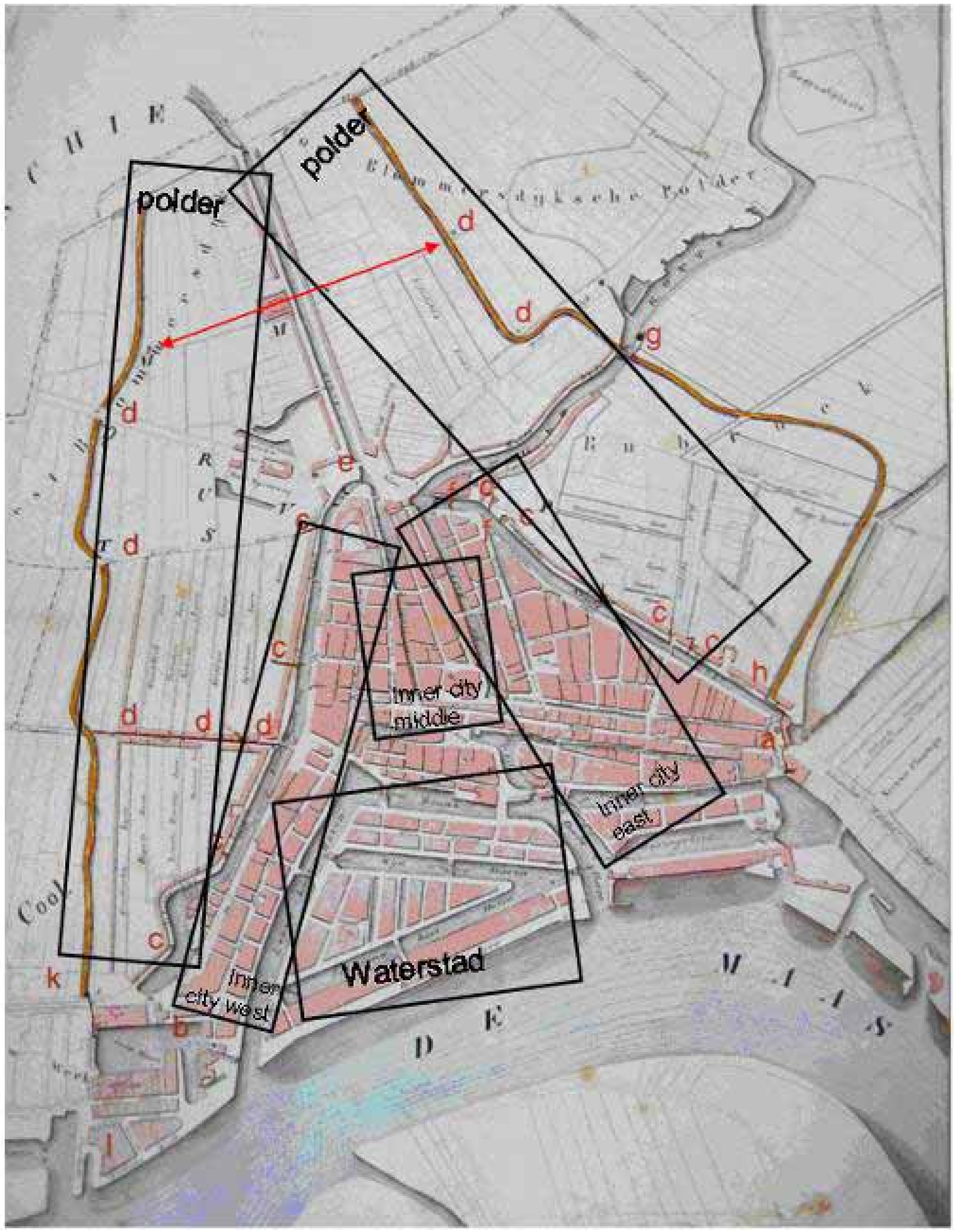
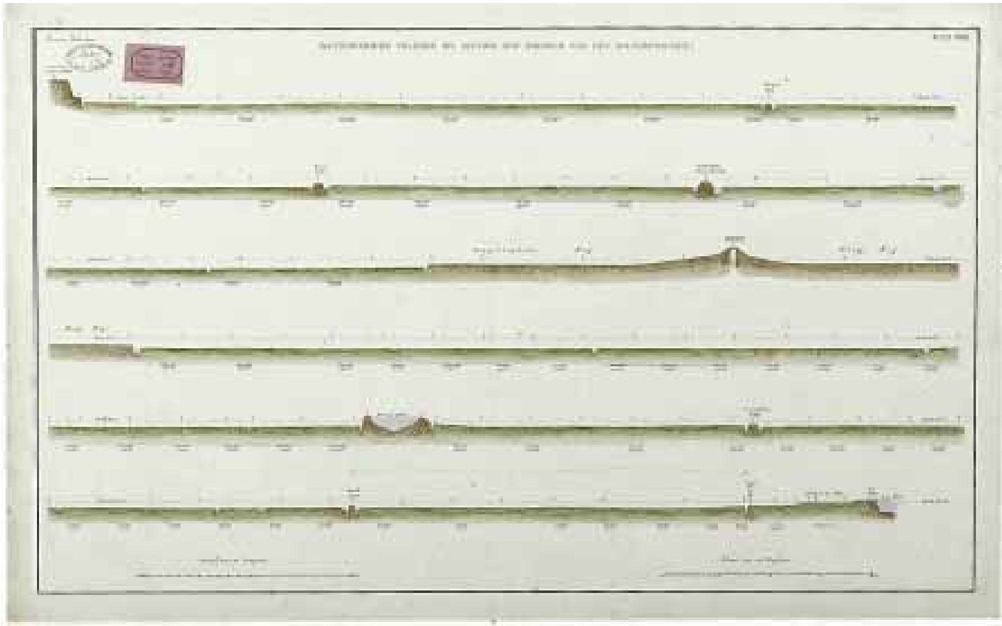
[248] GAR, OSA, 4963-4966, stukken betreffende het waterproject van W.N. Rose 1841-1863, Memorie van toelichting voor het Waterproject.

[249] GAR, OSA, 4963-4966, stukken betreffende het waterproject van W.N. Rose 1841-1863, Rapport F.W. Conrad and D.J. Storm Buysing 4 mei 1855



Picture 4.11 Explanation of the areas and the water management artifacts projected on the First *Waterproject* map.
Source: Municipal Archive Rotterdam with altertions by Author



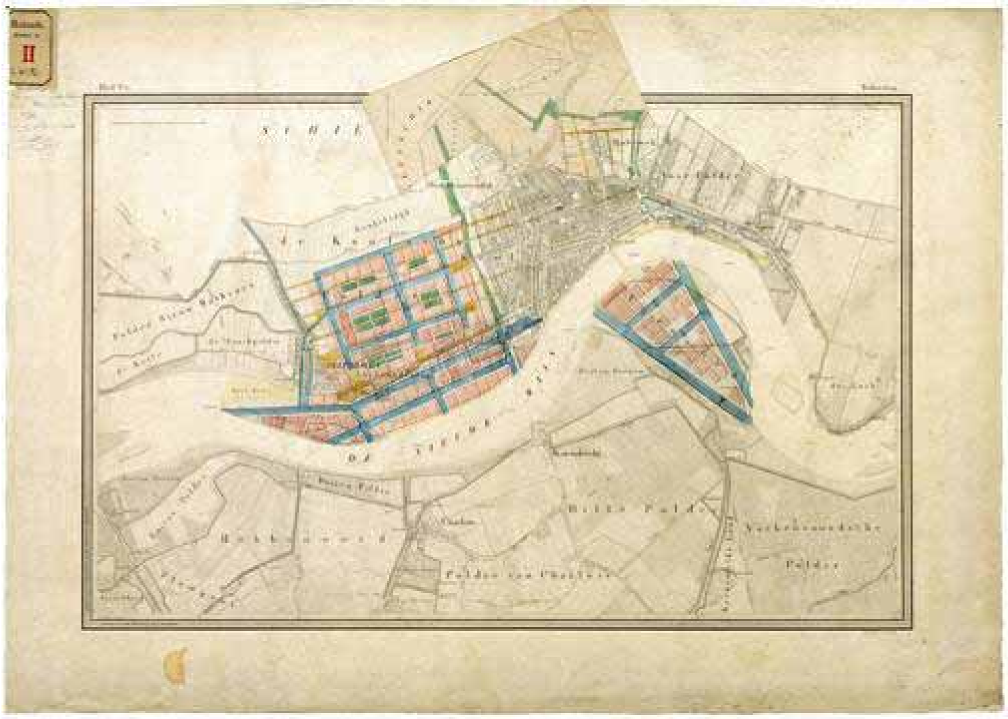
Picture 4.12 Section of the *Waterproject* to study the difference in height for improved flows
Source: Municipal Archive Rotterdam

Urban Design

The fifth aim of the *Waterproject* is to plan a street layout for the area between the watercourses and the old city rampart. This area is now available for development since the groundwater level is lowered from 1.60 m -R.P. to 1.80 m -R.P. Rose already prepared this fifth point after his first *Waterproject* in 1841, in his first Coolpolderplan of 1842. The reason for the projection of streets connecting the new urban structure to the inner city is to control the private developers. On the west side he draws Kortenaerstraat, Witte de Withstraat, Van Oldenbarneveltstraat and Aert van Nesstraat, 20 m wide. On the east side he draws Jonker Fransstraat, and three other (not realized) streets: at the height of what are now Meermanstraat, Schoolstraat, and Hugo de Grootstraat. And additional streets are also drawn but, due to the construction of the cattle market, never realized.

Surprisingly, on the inner side of the *singels*, often called *kades*, no roads are planned. Not until the 1870s is a road built along the Westersingel – Mauritsweg/Eendrachtsweg – by the residents, as the city board does not find it necessary and it is quite usual for streets to be financed by private developers.[250]

[250] Van Ravesteyn 1924, 113; H.A. van IJsselsteijn 1888a, 12



Picture 4.13 Coolpolderplan by Rose 1842, the Waterproject noted in green instead of the more figurative pink in the First *Waterproject* plan.
Source: Municipal Archive Rotterdam

The buildings along the east *singel* are not mentioned in the plan. The side streets are designated for labourers' houses; which are strictly forbidden along the *singels* and the main streets. For the western part, however, Rose is very explicit about the urban ambition, based on his first expansion plan, the Coolpolderplan (1842). In that plan he explains his ideals vividly and also adds a set of regulations, but never a real design. The building height per street, the number of floors, and regulations concerning sidewalks, balconies, and so forth are included. He even deals with the subject of which buildings styles are appropriate.[251] For the west side of the *Waterproject* he not only gives a set of conditions of street widths, street pavement, lighting, pumps, playgrounds, etcetera, but he has landscape architect J.D. Zocher[252] draw up a landscape design.[253] It is deemed suitable for building country houses or villas, because they will have a nice view of the *singel*, which contributes to the quality of residences in that area.[254]

[251] Berens 2001, 134-138.
[252] As a landscape architect Zocher had great expertise with designing luxurious residencies. From the 1820s he designed villa parks, and city expansions, especially the reconstruction of a city rampart into a park as in Utrecht. The Zocher firm was started in 1849 by J.D. Zocher jr. (1791-1870) and his son L.P. Zocher (1820-1915)
[253] Anonymous 1858
[254] Plan tot aanleg van nieuwe straten in de polders Cool en Rubroek, p.23. GAR, Plaatselijke Werken, inv.nr.3085.

Picture 4.14 Detail of the plan showing the country houses or villas.
Source: Municipal Archive Rotterdam

In a strategic move to ensure the realization of his urban ambition, Rose makes visualizations to sell the plan to the city council. He writes in his explanation of the plan:

> The appropriated lots offer more space than necessary for the dike and water course. The land that is left over can be used to make a pleasant park to enjoy walking. The gently waving walkways follow the gently waving water courses that accentuated by green structures make picturesque scenery.[255]

By adding the leisure function and the residences for better off residents in lovely green structures, Rose and Zocher made their intentions for this city expansion quite clear. The Zocher firm is not only committed to designing and constructing the project, but is also involved in the expropriation of grounds that are needed to realize the plan. The fact that the Zochers are involved with the economic aspects of the project must have resulted from their experience in making plans like the *Waterproject* take place. W.A. Scholten writes: ‘Finally it must be said here that in drawing up the plan a lot of attention is paid to making lots available that have a nice view and therefore can be sold for a good price.’[256] Save for a small part along the south side of Westersingel, the villa residential area is never really built. The housing shortage is too great at that time to utilize all the space for villas.

[255] GAR, OSA, 4963-4966, stukken betreffende het waterproject van W.N. Rose 1841-1863, Memorie van toelichting voor het Waterproject.
[256] GAR, Plaatselijke werken, inkomend stuk 219, 7 februari 1859, inv.nr. 704.

Picture 4.15 Westersingel and Mauritsweg around 1900
Source: Authors' postcard collection

Thirty years later, the way that Rose tried to prevent bad development by private developers is much appreciated by the director of Public Works De Jongh. He takes it even further and believes that the municipality should buy all the ground in the expansion area and develop it because: one should be forever ashamed that it [development by private developers] had not been prevented from happening.[257] The municipality can look ahead, while private developers live in the haste of the day. De Jongh recognizes this attitude of looking to the future in the people who gave Rotterdam harbours like Leuvenhaven, Oude Haven, Nieuwe Haven and Haringvliet around 1590, when the city was a tiny settlement with great faith in the future.[258] He considers the expansion of a trade city like Rotterdam as quite a different issue than the expansion of a more luxurious city such as The Hague. That city needs boulevards, alternating with parks and squares to attract people from out of town. When considering the expansion of Rotterdam it is most important to keep in mind that people do not come to the city to spend money earned elsewhere, but to earn money. And De Jongh defines the best conditions for a trade city: water and railways.[259]

Rose uses these conditions and the ideal of a water city in his Coolpolderplan 1858; he presents a whole new water city expansion on the west side of the city. This is the side that is expected to grow because it is closest to the existing harbour and to where new harbours can be built. This plan perfectly fits the street layout of the *Waterproject* and is made following the examples of the First Nieuwe Werk (1847), between Leuvehaven and Veerhaven, and the Second Nieuwe Werk (1854) between Veerhaven and the Park. These areas are realized with comparable dimensions and building regulations. Berens describes the specific design and regulation instruments

[257] Van IJsselsteijn 1888a, 5
[258] Van IJsselsteijn 1888a, 5
[259] Van IJsselsteijn 1888a, 5

used to realize the First and Second Nieuwe Werken, the ideal water city with large harbours, wide quays and streets, squares along the water, and big building blocks with regulated heights containing offices, warehouses and houses.[260]

Rose presents the plan with an accompanying report that studies the private ownership of land, building sizes, widths of streets, and so forth of the areas between the water courses and the city moats. This plan is the further development of what Rose is already planning in 1842; the survey made of the situation in the polders is remarkable for that time. Considering the fact that it is (almost) the first time that a polder is reclaimed from its polder board, and that pumps are necessary to keep the polder dry, it is understandable that Rose has to investigate as much as possible to enable him to answer the many questions the plan would raise.

Defining Urban Tissue

In the former chapter the development of a polder city, adjacent to a higher inner city core, is done with 'strict control'. The size has to be sufficient for a certain period of time and the grounds need to be exploited as efficiently as possible. This is also done for the *Waterproject*. The grounds needed to build the dike and waterways are bought by the municipality. Rose and Zocher come up with a way to make these grounds profitable: expensive houses along the *singel* and labourers' dwellings in the (narrow) backstreets. The open space and large-scale houses along the *singel* therefore contrast sharply with the dense areas behind it. That this spatial construction determines the social setting of the area is not taken into consideration and that this social setting still exists to this day underlines the importance of urban design. Still today Rotterdam has no bad and good districts, but good and bad streets in one district. The contrast in the areas along the *Waterproject* is particularly marked in the (current) use of the *singel*: residents along the *singel* use it as a green structure that is nice to look at, while the people that live in the dense areas use it as public space in which to walk or sit.

Before the Housing Act of 1901 private developers not only make the street plans but finance the building-site preparation, the roads and infrastructure. There is no legislation to direct these developments in a greater plan. The municipality constructs the infrastructure (building-site preparation, streets, water, gas and sewer) and afterwards takes care of its maintenance. This practice is not laid down in any law but is developed along the way, giving the municipality control of the plans (a way to make use of all the mud that was excavated in building the harbours) and the quality of the roads.[261] The municipality can manipulate the private developers with the threat of no connection to the sewer, gas and water systems and refusal to take over the maintenance of the streets. This practice of steering development with deals and threats works well because private developers need the best return on their investment (which is a loan) and well kept streets and houses with water, gas and sewer are crucial to

[260] Berens 2001, 138
[261] Van Ravesteyn 1935, 6

this.[262] The municipality purchases key lots to steer the spatial set up and uses ordinances for some guidance.

Picture 4.16 Oostblommersdijkpolder with proposed urban blocks (in pink) drawn over the polder pattern, from which the subsidence of houses can be predicted. It shows the sharp contrast between the open space and large-scale houses along the singel with the dense areas with smaller houses and streets behind it.
Source: Municipal Archive Rotterdam

The result is a small patchwork of developments that follow the polder pattern, representing land ownership. The lack of a greater plan and the optimal use of the grounds are secured in the polder pattern that also offers some structure: the landscape as master plan. The structure is emphasized by the dikes, which at the same time are the most solid structures on which to put roads. Also, the use of the polder pattern, in which the streets follow the lines of the ditches, is less expensive than introducing a new pattern.

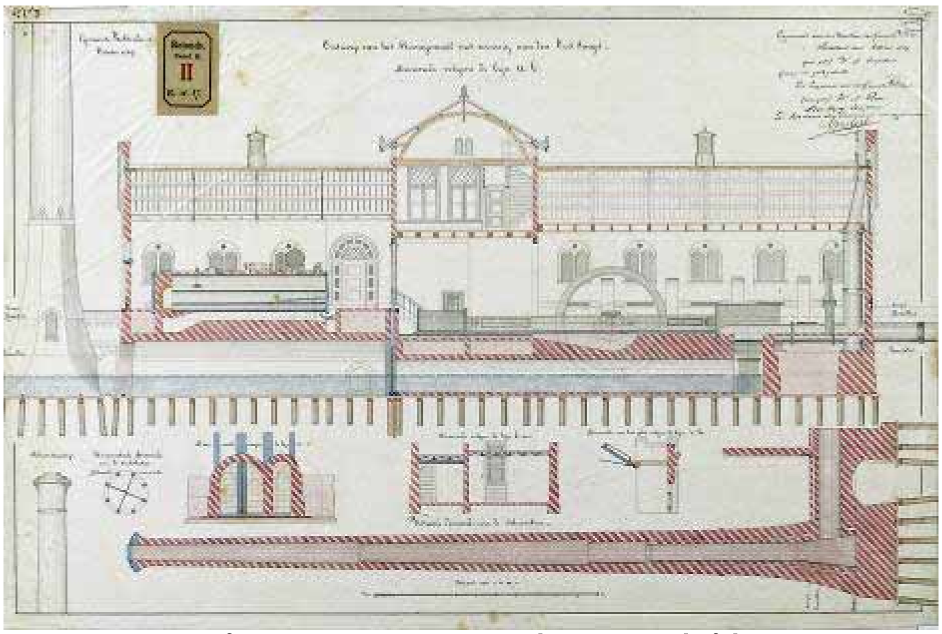
Urban Engineering

From 1860 to 1880 the area between the new water system and the old city triangle is developed. With high speed and low quality speculators build in high densities. The area is prepared by using the method of raising only the streets with sand. This method organizes a street pattern parallel or perpendicular to the pattern of ditches.[263] This way of building-site preparation causes subsidence problems, which are consequently solved by adding material (sand, but also rubbish, rubble, and so forth) to raise the grounds. This is done repeatedly over time. After the Second World War a large part of the inner and the polder city that is damaged is raised again with a 1-m layer of sand.[264]

To keep rents low, houses are built as cheaply as possible. They are built with a minimum width to keep the foundation costs down. A large part of

[262] Van Ravesteyn 1948, 150
[263] Nota actief bodem en bouwstoffenbeheer", deel II, Historische gegevens per onderscheiden Ruimtelijke Eenheid. (april 2002).
[264] Nota actief bodem en bouwstoffenbeheer", deel II, Historische gegevens per onderscheiden Ruimtelijke Eenheid. (april 2002).

the budget is used on foundations because of the soft polder soil.[265] The problems of building on peat are not such common knowledge that they can be calculated and applied to any project. Rose builds a hospital on the Coolsingel on 8000 m^3 of sand. He drives test piles into the ground to test the subsidence in the area. After a year the subsidence is much greater than he expected and after completion the hospital sinks on one side. The municipality does not blame Rose, because the expertise on pile foundations in peat is still very underdeveloped and he couldn't possibly have foreseen these problems, especially since he was working with a small budget.[266]



Picture 4.17 Design of a steam pumping station at the eastern end of the *Waterproject*.
Source: Municipal Archive Rotterdam

Slowly various ordinances are passed to enable the municipality to keep some control over the growing city. In 1857 a committee researches means of improving the polder and old city.

In the same year the first building regulations are drawn up on the basis of the Municipality Law of 1851, which organizes the administration of the municipalities. In the building regulations of 1857 (which are mainly aimed at organizing hygiene in the city), article 21 stipulates a fixed water level, and requires the grounds in houses to be raised above this level.[267] Interestingly, the stipulation on improving soil conditions is taken out of the regulations because the majority of the council votes against this proposal.[268]

In 1860 the building regulations are altered and building lines are introduced to control the positioning of houses on their plots, their heights, and the width of the streets. Sometimes houses are built almost on top of each other, allowing little light and air into the houses and the streets.[269] Basement houses are very popular because of the lower minimum floor

[265] Van de Laar 2000, 266
[266] Moscoviter 1996, 72
[267] Van Ravesteyn 1924, 126
[268] Segeren and Hengeveld, 1985, 26; and Gemeente Rotterdam 1919
[269] Van Ravesteyn 1924, 127

height (30 cm above street level), which makes it possible to build an extra room at the back yard that is not filled and therefore much lower than the street side.[270]

In the polder city houses of only two floors have foundations of frames or barrels without bottoms filled with *slieten* (branches). The ordinance of 1860 changes this practice by making pile foundation compulsory.[271]

Sewer

The new polder city, built between the city ramparts and the new watercourses, is completed in a period of ten years. However, the *Waterproject* does not solve the problem of polluted city water. Despite the fact that water is adequately flushed through the system, too much waste is dumped into the city water and it is not until 1890 that the hygienic circumstances are improved by the construction of a sewage system. Discussions about the type of sewer to build delayed the choice of a system.

The streets in the polder city all have ditches along them that function as an open sewer. W.A. Scholten, the new Director of Public Works, learns about the *système libre* during a study trip to Hamburg. *Système libre* is a tube system that uses differences in height to create a flushing stream. The Board of Health (established in 1854)[272] is in favour of the barrel system (gathering sewage in barrels that are collected by the municipality and can be sold as manure) but on 22 January 1863 the municipality decides to build the flushing system and a sewer plan is made.[273] The ditches are filled in, but instead of devising a system based on height differences and connected to the greater system, sometimes the ditches are part of the new system and built over, sometimes replaced by a pipe, but also just filled. This way of working does not lead to a sufficient sewer network system.[274] The *Waterproject* offers a solution for the dirty water on a higher scale but is undermined by this disorganization on a lower scale.

De Jong makes a plan in 1883 that is inspired by the *système libre*, but instead of counting on height differences, he employs sewer pumping stations. The new system is independent of the open water system.[275] Sewer pipes are placed on both sides along the water courses of the *Waterproject*. In the case of heavy rainfall, if the sewage system overflows the water surplus can be discharged into the water courses, which function as temporary storage. Three pumping stations are built; in the west, the east and the north; all connecting with egg-shaped sewer pipes. The groundwater level is again lowered. Rose lowered it from 1.60 m -R.P. to 1.80 m -R.P. and De Jongh to 3.25 m -R.P. and at the pumping stations to 4 m -R.P.[276]

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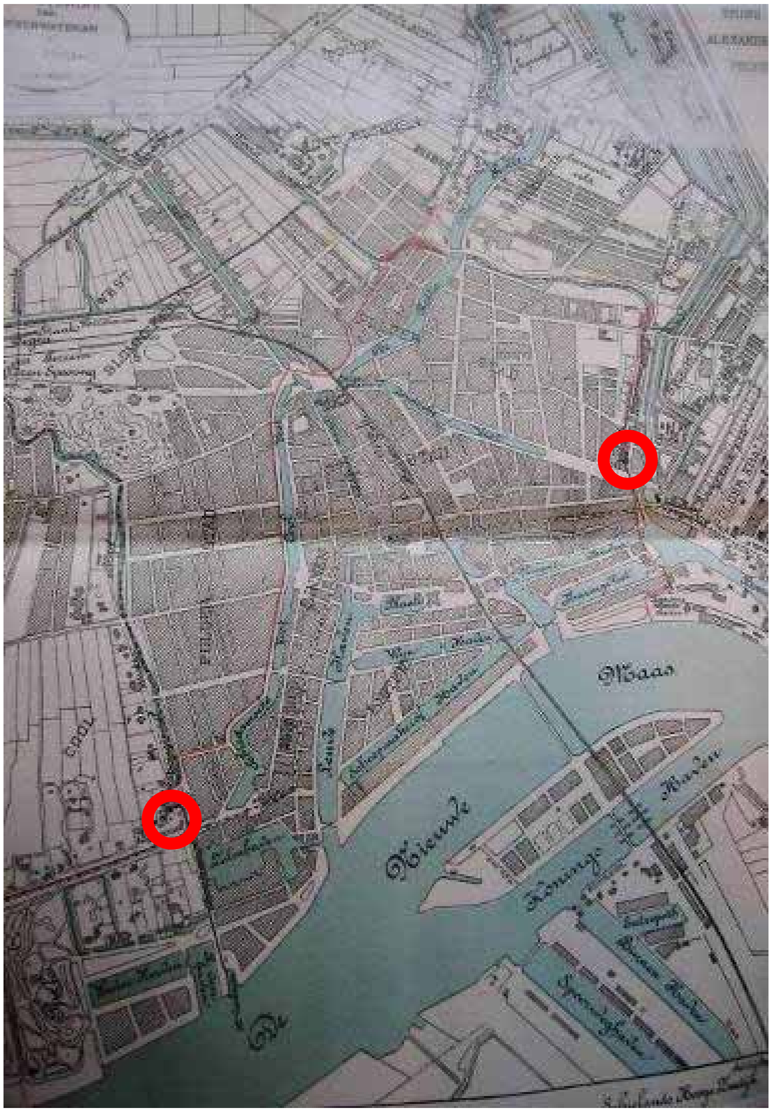
[270] Van Ravesteyn 1924, 128-129
[271] Van Ravesteyn 1924, 136
[272] In the Rotterdam Municipal Archive the Board of Health is archived under number 92. Here all aspects of the commission can be found. In the introduction to the Archive it is written that the Board was founded by the council on 15 June 1854 with three goals: 1) to advise the council into matters of public health, 2, to suggest improvements to the public health, and 3, to investigate dwellings and buildings which were suspected of bad quality. The Board had 13 members in 1854: two council members, two lawyers, two doctors, two natural scientists, two chemical scientists and three architects. In 1933 the Board was disolved.
[273] Van IJsselsteijn 1888b, 8
[274] Van Ravesteyn 1924, 141
[275] Van Ravesteyn 1924, 146
[276] Van Ravesteyn 1924, 147

Picture 4.18 Construction of the sewer in the inner city around 1870.
Source: Municipal Archive Rotterdam

In 1884 the Board of Health presents a plan for a sewer system for rainwater: it is stored in large pits that are connected to each other by gravel beds that filter the water before it is discharged into the open water system. House sewers have a separate system.[277] It is a pitty that they did not implement this system because that delivers a much flexible system that maybe could deal with the current change in water balance. However, the third building ordinance of 1887 lays down more technical and sanitary stipulations concerning drinking water and sewer systems and a combined system is eventueally realized.

The drinking water problem is solved by Rose's successor C.B. van der Tak, who builds the municipal drinking water system in 1874. This system – which is mainly built to flush the sewer system and only secondly meant to supply drinking water – and the realization of the sewer system, causes the *Waterproject* to lose its purpose as a water refreshment system, since no sewer water goes into it anymore. Also, the filling of the city moats means that no Maas water can be let into the water courses of the *Waterproject* and another source has to be found: the Noorderkanaal.

[277] Van Ravesteyn 1924, 148



Picture 4.19 Connection of the main sewers to the pumping stations (red circle) in 1889. Source: *De Ingenieur* 1889

In 1889, H.A. van IJsselsteijn writes an article in *De Ingenieur* about the improvement of the water in the inner city by the construction of the sewer. The pumping stations of the *Waterproject* are improved to use for the sewer as well and the waters of the *Waterproject* are disconnected from the sewer. Most rain will also be caught in this sewer. The power of the new engine is calculated to process 40,000 litres of drinking water and 45 mm per m^2 of rain per day, which is quite a lot compared to other cities. Another factor that influences the calculations of the power of the pumping station is the fact that due to the bad soil conditions, the sewer cannot be too large and heavy; otherwise it will have to have a pile foundation. That would be an expensive enterprise, since the piles in Rotterdam have to be 15 m to touch the stable layer of sand and subsidence is such that streets are raised every four years. If the sewer is built on piles, the subsidence will be partial and streets will have to be reconstructed completely, bringing along higher costs. The plan shows the connection of the main sewers to the pumping stations.

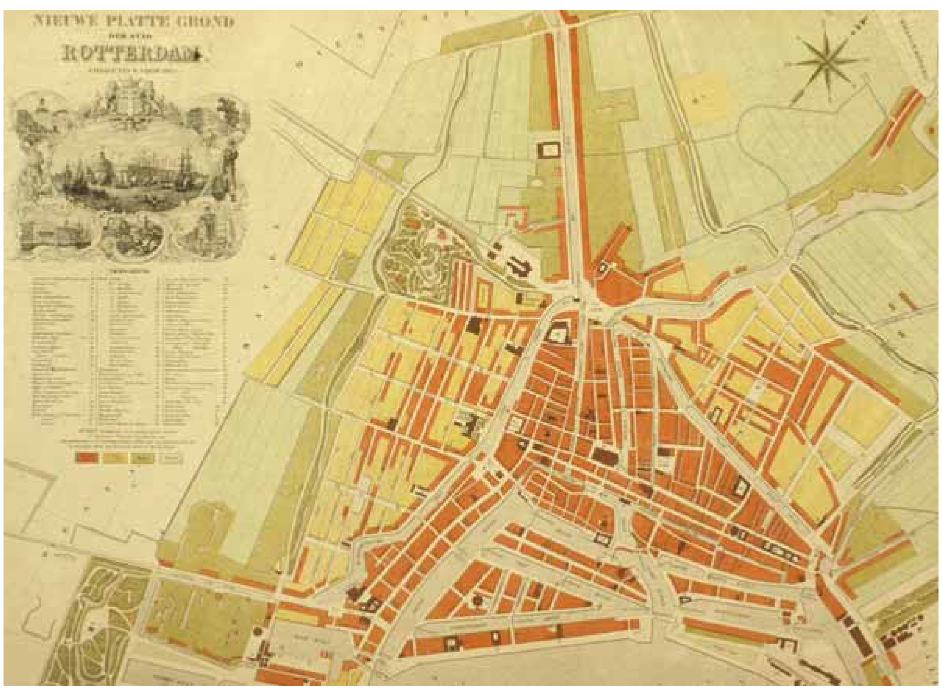
It also gives a nice insight into how the city developed in the past ten years and how the construction of the sewer closes off parts of the waterways of the *Waterproject*.[278] .

Developments after Rose

The way Rose and Scholten combine hydrological knowledge with city design is still a great example, furthermore it marks the end of a tradition of spatial design of hydrological constructions. They use the characteristics of the landscape, the pattern of ditches and dikes, for the design of the city. The water structure is therefore the backbone of the expansion.

In 1855 the title of City Architect is changed to Director of Public Works. Rose leaves this position in 1858 and his successor is W.A. Scholten (Rose's advisor, not to be confused with the above mentioned J.A. Scholten). In 1857 Scholten proposes some adjustments to the *Waterproject*: replacement of the pumping stations, larger steam engines and instead of a culvert a bridge over the railway. Scholten dies suddenly in 1861 and C.B. Van der Tak fills his position until 1878. He concentrates on building the sewer. In 1879 G.J. de Jongh takes over until 1910.[279]

Immediately after his appointment and shortly after the town is ravaged by yet another cholera epidemic, De Jongh makes plans to methodically introduce a system of sewers. To this end, he raises the capacity of the pumping stations in the *Waterproject* so that they can work for the sewers as well as the singels. It is only once the sewerage and drinking water facilities are in place that cholera is eradicated from the city for good.



Picture 4.20 Rotterdam in 1865 already showing the urbanization between the old city moat and the new *singels*.
Source: Municipal Archive Rotterdam

[278] Van IJsselsteijn 1889, 103
[279] See the chapter about the era of De Jongh Nieuwenhuis 1955, 89-162

Originally, the waters of Noordsingel flow past today's Noordplein, linked with Crooswijksesingel by a culvert under the Rotte. In 1888 De Jongh proposes filling in the stretch of Noordsingel between the Rotte and Hofdijk and building a brick-walled main sewer there. The small pumping station serving Blommersdijksepolder is superseded by a new one that can empty the sewers as well as drain the polder. By connecting the main sewer and Noordsingel with a lockable culvert, the *singel* can, in an emergency situation, also be pumped by the new steam-driven pumping station. This also serves to connect all three pumping stations, northern, western and eastern.[280] In 1891, after De Jongh's second proposal, the council decides to fill in the watercourse.

There are other advantages to filling in this section besides laying the sewage network. The original *Waterproject* bridge over Noordsingel, level with Hofdijk, is in a sorry state and the narrow Hofkade with its steep bank is a danger to the swelling volume of traffic.[281] The filling-in strategy also creates space for more public greenery which will give a new look to the entire area:

> . . . a place where the tightly packed local population can enjoy the open air in an attractive surrounding for a change. As I see it, the benefits of small patches of green, such as are already to be found elsewhere in our town, are immense. The fact, for that matter, that the seating placed there is regularly occupied is proof enough that these public gardens are no luxury. It would be hard to find another place suitable for public greenery in the large working-class area extending north-east from the Schie and soon built-up as far as Hillegersberg; and yet one green oasis in the desert of sun-baked streets is certainly needed in this district far from every park.[282]

Rotterdam applied this method of expansion once more half a century later when Heemraadsingel (1910) is developed. Succeeding the seventeenth-century city triangle and the *Waterproject*, the Heemraadsingel is the third Rotterdam expansion with a water ring. This site is prepared in the same way as the *Waterproject*, but planned with more space and provisions for sports and recreation. However, the trajectory is much broader and the traffic network is not located alongside the *singel*, but rather runs through the city entirely based on its own logic.
The Heemraadsingel is the second parallel road in the plan, which has four main aims:

1) A waterway is much more beautiful than a dusty road and breaks the monotony in a neighbourhood of roads and has the same effect as wide streets in that it brings light and air into a dense city.
2) The waterway can, just like the Westersingel, serve as storage when a severe rain storm occurs.
3) The singel makes a more easy transition from polder to city; it cuts

[280] GAR, APWGW, I.S. 1891, no. 2159
[281] GAR, APWGW, I.S. 1891, no. 2545
[282] GAR, APWGW, I.S. 1892, nos. 3327 and 3698

through the main water system of the polder and ensures a stable water level in the polder.

4) The new singel is connected to the *Waterproject* by the Essenburgsingel, so that the steam pumps of the *Waterproject* can also pump the Heemraadsingel in the event of failure of that steam pump.[283]

The *Waterproject* connects a park in the west with a park on the east side of town and forms a green ring around the city. This concept is popular with J.D. Zocher Jr, who is inspired by the plans for Paris by G.E. Haussman and J. Alphand.[284] The 'green belt' concept of course becomes popular in England at the beginning of the twentieth century with the ideas of Ebenezer Howard. In the Netherlands an important incentive for urban design and hygiene (light and air) in the city is the Housing Act of 1901 (effective from 1902) instigated by the Board of Health. It changes some of the important forces that shaped Dutch cities in former centuries. In the first place it stipulates that cities with more than 20,000 inhabitants are obliged to make an expansion plan. Prohibiting private developers from planning buildings and streets – which Rose and De Jongh had already tried to do – is now laid down in a law. Secondly, municipalities can now lend money to housing unions and private persons to stimulate the building of very necessary houses. In this way it becomes possible to build housing on a larger scale and cut back costs. Slowly the tradition of independent houses built next to each other changes into one of large city blocks of apartments. The quality of these houses is controlled by the Board of Health, which has become an official state service with controlling powers.[285]

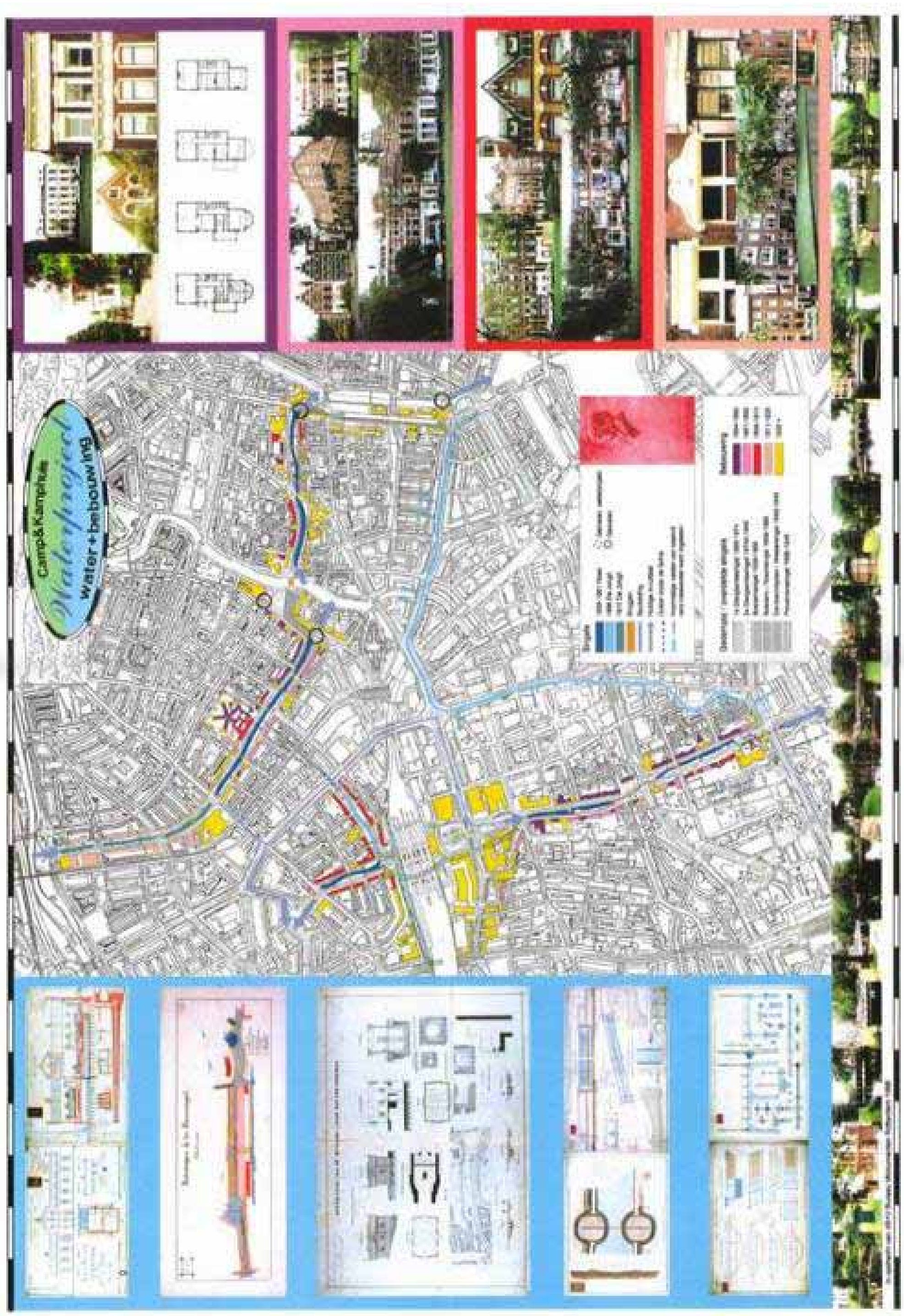
The Waterproject in 2011

In 2000 the *Waterproject* is rediscovered as a green lung in the dense city and as an ecological structure.[286] The new *Singelplan* enforces this function by restoring the green structure. Besides the green structure the water function of the *Waterproject* and its architecture-historical value are recognized and steps are taken to instate it as a protected monument. When walking along its route, the nineteenth-century city comes back to life.[287]

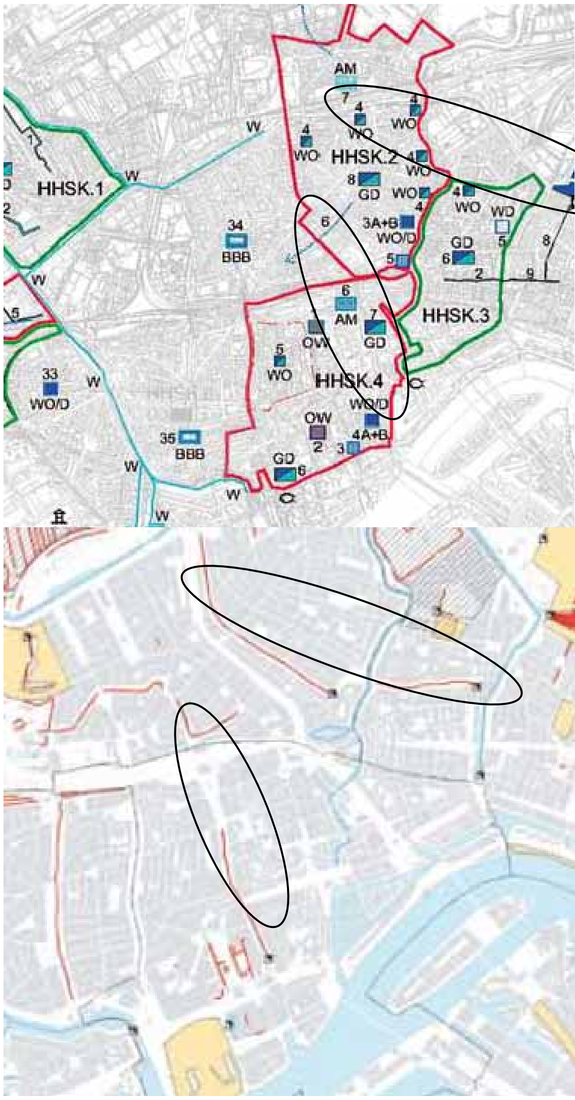
The *Waterproject* is still essential in the discharge of sewers in the event of a severe rainstorm. The pumping stations have been replaced by induction engines but are in the same locations, pumping the water courses. In 2001 the singels of the *Waterproject* fall under the supervision of the Schieland Water Board (from 2005 joined with Krimpenerwaard). The connection to the *boezems* of this Water Board, Rotte and Schie, were made years before. In the eastern part the water flows via the Rotte to the Maas.

[283] Van IJsselsteijn 1888a, 10
[284] Oldenburger-Ebbers et al. 1998, 389; Helmink Habes 1995, 7-8
[285] Van de Laar 2000, 267
[286] In 1998 Camp & Kamphuis researched the quality of yje trace to see if it is liable for a protected status.
[287] To show that the Waterproject is still a route through the city that shows nineteenth century Rotterdam a walking guide is made: Hooimeijer and Kamphuis 2001

The *bypass* that is constructed in the 1870s around the zoo is filled in after the zoo moves to Blijdorp (1940). The pipe that is placed under the Weena between the three parts of the *Waterproject*. It is possible that the culvert under the former Schie still has a function in this.



Picture 4.21 Overview of the state of the project in 1998
Source: Camp & Kamhuis 1998 and the Schieweg still makes the connection



Picture 4.22 Areas around the *Waterproject singels* are part of three water management units of the *Waterplan* 2. In the plan the *singels* of the *Waterproject* provide water quality.
Source: Waterplan 2

Evaluating *the Waterproject* on its current performance within the water challenge of Rotterdam using the information given in the *Waterplan 2* (2007) the water structure plays an important role. It now forms the buffer when a heavy rain storm floods the sewer.[288] Due to altering of the general water system in the city since the nineteenth century the different parts of the *Waterproject* are situated in different water management units. For each of these units different issues are defined in the *Waterplan* 2 shown in picture 4.22.

The measurement that is rolled out all over the city is a green roof program. Green roofs delay the water discharge and keep the sewer from overflow. Now, the overflow is done in the *singel* system causing a water quality problem.

[288] Gemeente Rotterdam et al. 2007

Picture 4.23 Artist Impression of the Green Roof Program
Source: Municipal Rotterdam

In the district to the west of the centre (HHSK.4) two underground reservoirs (OW) in the Museum Park (10,000 m^3) and under Kruisplein (2700 m^3) are proposed, of which the first - see picture 4.24 - is realized in 2010. Next to these several water squares (WO) green roofs (GD) and additional measures such as enlargement of the pumping capacity, a separate sewer system and discharge of the water to Essenburgsingel will be carried out. [289] A water square is a temporary reservoir in the public space that is slowly drained, see picture 4.25, and like a green roof has a delaying effect on the discharge of water to relief the sewer and keep it from overflowing.

Also in area HHSK 3 the water squares will be used to relief the sewer system during heavy rain storms. In the old city triangle (area HHSK. 2) deep (10,000 m^3) and shallow (4,500 m^3) water squares are planned in the urban tissue. The pumping station of the Noordsingel will be enlarged and the discharge of the Kleiwegkwartier will go through a new system, creating new storage. Research will be done into the surface water and discharge to Blijdorp.

[289] Gemeente Rotterdam et al 2007

Picture 4.24 Underground parking and water storage in Rotterdam.
Source: Municipal Rotterdam

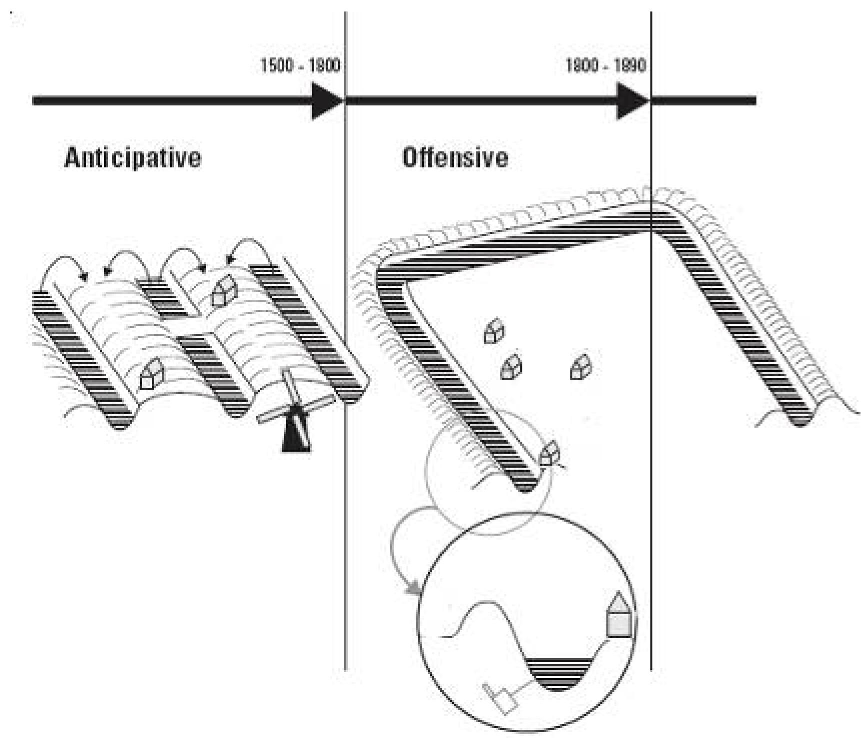
Picture 4.25 Water square
Source: Municipal Rotterdam

The Fine Dutch Tradition: Episode Three

The era of the Offensive attitude towards the natural system is characterized by the accumulation of people in cities and the development of high-tempo processes by machines, defined by the systemization paradigm. This paradigm gives insight into how the multiple demands of dynamic cities can be integrated by one urban plan tuning the natural, cultural and technical systems – and made profitable.

In this Phase the City Architect has to deal with large-scale projects like the hygiene in the city and the introduction of infrastructures like the railways and the sewer. The urban strategy is to bring good things together and group polluting functions (abattoir, cemetery and industry) outside the city. Rose, Van Nifrik and Kalff represent the civil engineering side of urban design that characterizes the profession in the nineteenth century.[290]

After the former Phase in which urbanism followed the physical geography, in this Phase a start is made with a new approach of influencing the physical geography in the sense that the water is not drained but pumped and the groundwater level is artificially lowered. Pumped city water becomes part of the public space and only roads are raised, causing the introduction of new building typologies. This polder principle is a new method of building-site preparation made possible by the new power.



Picture 4.26 From Urban Concept (chapter 3) to the *Waterproject* polder principle
Source: Author, drawn by Stella Smienk

[290] Hoogenberk 1980, 56

The Offensive Phase is the start of developments that undermine the character and quality of the Fine Dutch Tradition. The physical relation between city and landscape remains strong, the rules of water management and the landscape are still the basis for the city design, with the addition of the force of steam. In that sense the new force does make the element of strict control even stronger, systemizing it, leading towards the developments in the twentieth century where, as will be shown in the next chapter, the ruling thought becomes the idea that everything can be man-made: *maakbaar*.

The *Waterproject* is one of the first large-scale city expansions carried out with conscious consideration of urban design and the use of the newest technology, the steam engine. Mostly due to the fact that the designers Rose and Scholten are aware of the water and soil conditions, and the fact that the polder pattern represents the ownership patterns, the landscape structures are used for the urban design. The relation between the technology of draining (polder structure and differences in ground levels) and the overall idea about the shape of the city (following its original triangle) in this plan is still remarkable today.

By introducing public space and the coordination of important infrastructure the *Waterproject* breaks with the usual way of things done at that time. The 'Fine Dutch Tradition' is the ability to control the waterworks and integrate them with other urban challenge. The way the landscape structure and the water system are used to give structure to the city expansion, urban engineering, is characteristic of the Fine Dutch Tradition.

Chapter 5: Accelerating Powers (1890-1990)

Man can make everything possible

The new power of steam initiates a scale change, acceleration, industrialization and urbanization halfway through the nineteenth century. At the end of the nineteenth century the new powers of the combustion engine and electricity add to all these developments and accelerate them.

The combustion engine (diesel and petrol), electricity and the development of soil mechanics at the beginning of the twentieth century are the changing forces of the Manipulative era. Besides the shifting sources of power (from steam to diesel, oil, gas and electricity) in drainage technology, hydraulic and hydrologic technology also develops. Scientific research on soil mechanics adds to the development of better and more refined ways of building-site preparation, and the enlargement of machines to move ground makes it possible to realize them. Following the Phase of the Offensive attitude towards the natural system, the control becomes absolute in this Phase! (Or so we thought.)

The attitude of manipulation is not restricted to the natural system, but is the leading principle applied to all sectors, including social structures. It is not called manipulation, but known as *maakbaarheid*, a Dutch term that means 'man can make everything possible'. Especially after the Second World War this idea becomes very strong and, in reaction to the period of economic depression in the 1930s and the experience of the devastation of war, it is embraced with euphoria: the world will be a better place, society will be made into a trustworthy institute and cities will make people happy and well-functioning.

The development of scientific knowledge at the end of the nineteenth century underpins these ideas. In 1888, the journal *De Ingenieur* starts reflecting on the professionalization of the civil and (slowly disappearing) military engineer. That professionalization has also become a specialization and leads to division of engineers and urban designers is an important issue in this chapter and the three that will follow, especially since polder cities are the materialized examples of this division.

The division between the disciplines becomes absolute with the Third Industrial Revolution starting in 1908 and continuing to 1947 when petrol, chemicals, the internal combustion engine and electrification are the foremost forces. The post-war boom, from 1947 to 1991, is when the rise of mass production of consumer goods and electronics, like the car, telephone, television and airplane, takes over.

The First and Second World Wars result in a strong desire for – and consequently stabilization of – a national state wherein the social structures are well defined and under control: the welfare state. The national state is responsible for the social, economic and spatial order. It means the start of large-scale national spatial plans in which the Netherlands as a whole is planned. This is also expressed in water management, which becomes well organized on a larger scale; projects like the Afsluitdijk (the dike built to close off the Zuydersee after a major flood in 1916) and the Delta Plan (the answer to the disastrous flood of 1953) are the physical proof of this.

These large-scale water management plans enable the development of cities in the western part of the low-lying country. Around 1900 nearly a quarter of the Dutch population (in total 5.2 million people) lives in the major towns of Amsterdam, Rotterdam, Utrecht and The Hague.

The step to a modern industrialized society carries with it a concentration of industry and labourers' houses in the towns, causing problems such as hygiene, densification and low-quality housing. These negative effects of industrialization demand better organization of the city and the Housing Act (1901) is the first legislation that pleads for a discipline like urban design by way of the formal requirement of an expansion plan. It is only then that urban designers (trained architects like H.P. Berlage) and urban design become more visible within the spatial order. But it takes until 1947 for them to become well accepted as players with their own discourse and university departments.

The Housing Act focuses primarily on the poor-quality housing built in the former Phase, when the practice changed to building for the free market. This greatly affects the quality of housing, which becomes a special aim within the new municipal organization. The Department of Public Works is split, following the path of disciplinary division, into technical and urban parts: departments of urban planning and housing. In this engineers, as the keepers of technical innovation, start to be involved in social questions and improve their social position.[291]

Modernization of the cities is done with the focus clearly on the improvement of hygiene. Light and air are the architectural paradigms of this focus and functional separation of the urban strategy. The issues at hand are car mobility, which takes up a lot of space and simultaneously changes the way the city is used, and industrial building methods.

This chapter introduces the relation between the disciplines, the general urban developments and the history of building-site preparation from 1890 to 1990, the Phase of manipulation. However, while technology develops within the same trends and attitudes of acceleration, there are very different urban typologies recognizable. As will be shown, these three urban typologies are strongly connected to different methods of building-site preparation and represent a certain stage in the accumulating influence of technology on the building and design of cities. The conclusion of this chapter will be the stepping stone for the following subchapters: 5a *Accelerating Machine Power* (1890-1940), 5b *Accelerating Manpower* (1940-1970) and 5c *Accelerating Flower Power* (1970s). These chapters connect the method of building-site preparation to the urban typology of those three periods.

[291] Lintsen 1985, 49

Civil Engineering versus Urban Design

In the first year of *De Ingenieur,* H.W. Nachenius writes about a competition for the expansion behind the National Museum and calls it a *stedeplans* which is the forerunner of the term *stedebouw*. He can not think of any place of education other than the Polytechnic School in Delft where the projection of *stedeplans* or urban expansions, is taught. When he studied there, there is one class in urban design (here he calls it *stedenbouw*)[292] taught by E.H. Gugel (1832-1905):

> Just like the most comprehensive handbook about the art of building - that does not give the experience of designing itself - is not enough to make an architect, the most comprehensive literature about urban design is not enough to shape an urban designer; this is a difficult issue because for urban design the broad spectrum of knowledge of the engineer needs to be merged with the fruits of study and exercise of the experienced aesthetic designer.[293]

The profession of architecture slowly, but a lot faster than that of urban design, becomes a discipline within spatial planning. The first associations are established: the *Maatschappij ter Bevordering van Bouwkunst* (Society for the advancement of the art of building) (1841) and *Architecura et Amicitia* (1855).

When the Polytechnic School becomes the College of Technology in 1905, architecture acquires an independent faculty. The architects are schooled in very technical subjects, in company with the Faculty of Civil Engineering, and have obligatory courses such as water construction and surveying that are more connected to the practise of city building.[294] The architecture students are, in the eyes of their more technically inclined fellow students at the Faculty of Civil Engineering, the ones who can draw beautifully and have a more artistic character.[295]

In the discourse of architecture there are ideas and ideals about the city, however not as a specific discourse. The discourse on urban design and the building of a theoretical foundation starts under pressure of an enormous urbanization issue first in Germany and England with publications such as *Stadt-Erweiterungen in technischen; baupolizeilicher und wirthschaftlicher Beziebung* (1876) by R. Baumeister, *Die Städtebau nach seinen künstlerichen Grundsätzen* (1889) by Camillo Sitte and *Städtebau* (1890) by Joseph Stübben. Baumeister's ideas about city expansions are dominated by traffic and public health, Stübben is the first to approach urban design as a process and in its spatial context and Sitte puts forth the artistic principles of city

[292] *Stede* in Dutch refers to the human habitat, thus *stedebouw* is also the design of villages and not only of cities which is *steden* in Dutch.
[293] *De Ingenieur* (1886), 339. In Dutch: Maar evenmin als het uitgebreidste handboek over bouwkunst, zonder oefening in het 'projecteeren', voldoende is om een architect te vormen, is de omvangrijkste literatuur over stedenbouw, op zich zelve, in staat den ontwerper, den keurigen ontwerper van stedelijke uitbreiding te vormen; een vraagstuk, te moeilijker, omdat veelzijdige kennis van den ingenieur moet gepaard gaan aan de vruchten van studie en oefening van den ervaren aestheticus.
[294] Steenhuis 2009, 6
[295] De Ruijter 1983, 23

expansions.[296]

In England Raymond Unwin writes his famous work *Town Planning in Practice, an Introduction to the Art of Designing Cities and Suburbs* in 1909. One chapter deals with the subject of the survey, which according to Unwin cannot be separated from an artistic design, but has an autonomous role in the design process.[297]

In 1880 the first Dutch publication about city expansion appears: *Bijdrage aan kennis van de stedebouw, eene populaire studie*. (Adding to knowledge of urban design, a study) by engineer-architect H.W. Nachenius. He introduces the Dutch term for urban design *stedebouw* meaning 'beautification of place' and applies it to new expansions and old inner cities. He is concerned with the quality of plans: 'Thank God there is already a fruitful co-operation . . . between professionals of different disciplines,' because 'technical, sanitary, economical and aesthetic demands are interwoven in the urban design . . .'[298]

Nachenius emphasizes the functional aspects – technical, sanitary and economic – of the urban design. *Hedendaagse Stedebouw* (Contemporary urban design), written by J.P. Fockema Andreae, is published in 1912, followed a year later by a dissertation by W.B. Peteri about government meddling, neither as complete as the German and English literature. *Stedebouw* (Urban Design) (1926) by J.M. de Casseres also does not reach the conceptual quality of the foreign books.[299]

Not by coincidence, the urban design discourse starts at the same time the discussion of the hygienic city begins, guided by the health commissions concerned with the hygienic condition of cities. One important result of the fight for a hygienic city is the Housing Act (1901), which is also one of the most important administrative impulses for the discipline of urban design to become an independent profession with specialized tasks and needing separate services, schooling and associations.[300]

Even though the law is primarily written to ensure the quality of new dwellings, it also demands an expansion plan and provides the means to prohibit building and to claim land. During the first decades of the twentieth century the expansion plan is gradually developed into zoning plans. Anticipating this, an important modification is made in 1921 when the right to reject building licences is also included.[301]

Municipal departments for urban design are set up independently from Public Works in The Hague (1918) Amsterdam (1928) and Rotterdam (1931), to develop new aesthetic and/or scientific fundamentals for the discipline. In the 1920s another issue comes up: urban design as a science. For Amsterdam and Rotterdam this is the reason to set up a department independent of the technology of building and constructing cities (Public Works). The argument is founded on the consideration that urban design is beyond technical issues and is a more socioeconomic, political and cultural

[296] De Jong and Meyer 2000, 17
[297] De Jong and Meyer 2000, 19
[298] Nachenius 1880
[299] De Jong and Meyer 2000, 21
[300] Ibelings 1999, 6-20
[301] Meyer z.d., 9

profession.[302] Urban design, in the general consensus, develops from a purely technical discipline into an art, the art of composing different components of the city into a harmonious unity. This should be done by the synergy of scientific research and designing skills.[303]

Public Health Engineer

At the end of the nineteenth century the industrial developments lead to a more differentiated profile of the engineer. In *De Ingenieur* the different subjects of expertise form the structure of the magazine – in 1889 mechanical engineers and ship builders get a separate appendix, followed in 1895 by electrotechnicians and in 1903 by chemical engineers. Compared to former centuries, the profession of engineer shows a move to a more social attitude. Due to the fact that a lot of different expertises develop they are also connected to many different parts of society. The military engineer works with large infrastructures on a national scale, such as channels and railways; the civil engineer is concerned with infrastructure on a city scale, like the sewer.[304]

In *De Ingenieur* many articles are written about this subject.[305] The connection is made to the Boards of Health (established in 1854) on the theme of the hygienic city, the concern for the health of the residents in dense inner cities. The commitment of the engineers is such that as early as 1891 a proposal is made for a chair of 'Hygiene' at the Polytechnic School in Delft. Engineers even try to push the profession of medicine off its pedestal as being the major influence on health care.[306]

Civil engineers see their task chiefly as a social one, the technical aspects of social questions as their main concern. This legitimizes civil engineers in line with military engineers, who see themselves as the connection between capital and labour, as part of the upper class but working for the lower class.[307] After the 1880s military engineers become the less dominant group within the engineering discipline. Their heritage is impressive: a better financial situation for the engineer, a State Water Department that is independent from the provinces, one head of the department, formal competence and a better positioning of the corps in government. At the end of this Phase the civil engineer is aiming at a better position of the engineer in society by claiming social issues.[308]

Division

The improved hydrologic and hydraulic achievements in the first two decades of the twentieth century in sluice and dam building are based on the capacity to apply steam power and, important for building polder cities, to mechanically move earth on a larger scale. At the same time the application of reinforced and prestressed concrete, riveted and welded metal structures, electricity and rationalized building processes modernizes the way that

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[302] De Jong and Meyer 2000, 23
[303] De Jong and Meyer 2000, 30
[304] Lintsen 1980, 298
[305] Lintsen 1980, 306 and *De Ingenieur*: 12 (1897) 442-443; 6(1891)444-446; 1(1886)455; 4(1889)23, 216; 5(1890)228; 6(1891)67; 9(1894)274, 299, 311, 416, 462, 613; 7(1892) 71
[306] Lintsen 1980, 311
[307] Lintsen 1980, 314-320
[308] Lintsen 1980, 325

water is pumped, sand is dredged and moved, and quays, sluices and dams are designed.[309]

The technology becomes more advanced, more complex. Different organizations are set up to represent different interests, and different fields of knowledge. In the years 1913 and 1914 the *Bouwkundig Weekblad* (Architectural Weekly Magazine) reports the discussion on the division of labour between engineer and architect with regard to urban design: the engineer supplies the utilitarian facilities and the architect the aesthetic framework.[310]

This division between the two disciplines that work on the hydrologic constructions (cities) not only increases but becomes institutionalized in education, interest groups and associations and in governmental organizations.

For the civil engineers there is *Instituut voor Water Zuivering* (Institute for Wastewater Treatment, 1920), the *Hydrodynamisch Laboratorium* (Hydrodynamic Laboratory, 1920), the International Association for Hydraulic Research (1935) and in 1924 the development of new sources of energy provokes a discussion about electrical or diesel drainage of the polders and, in order to combine expertise, the *Technisch Adviesbureau van de Unie van Waterschappen* (TAUW, Technical Advice Bureau of the Association of Water Boards) is founded. During the period 1930 to 1939 there is a consolidation of the achievements and a further development of civil engineering technology, based on model-based and mathematical analyses and prognoses.[311]

The developments in improving soil conditions for city building take flight after the Second World War and are institutionalized by the establishment of the department of soil mechanics in the *Koninklijk Instituut Van Ingenieurs* (KIVI, Royal Society of Engineers in 1949. Major city expansions cause a significant increase in building on territories with insufficient and unknown soil conditions, and on wet and weak soils.

Engine power becomes an important factor in the pumping of sites while buildings are under construction. The movement of sand to use as stabilization material to raise building sites, so that they can be built 1.20 m above groundwater level, is profoundly improved by the method of 'hydraulic filling' of sand. This means a scale enlargement in building-site preparation that is used in the huge building project after the Second World War.

The organization of urban designers takes some steps, starting with the advisory committee for the housing corporations in 1913 and the second step is the *Nederlandsch Instituut voor Volkshuisvesting* (Netherlands Institute of Housing), the current *Nederlands Instituut voor Ruimtelijke Ordening en Volkshuisvesting* (NIROV, Netherlands Institute for Spatial Development and Housing), in 1918.

Within this institute a separate commission on urban design is set up in 1921 also changing the name of their journal *Tijdschrift voor volkshuisvesting* (1920, Journal for Housing) in 1923 to *Tijdschrift voor*

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[309] Schot 1998, 59-63
[310] Ibelings 1999, 22
[311] Schot 1998, 178 and 203

volkshuisvesting en stedebouw (Journal for Housing and Urban Design) and the name of the institute to *Nederlandsch Instituut voor Volkshuisvesting en Stedebouw* (Netherlands Institute of Housing AND Urban Design). There are strong connections to the International Federation of Housing and Town Planning consolidated in keeping with the International Conference on Urban Design in 1924 in Amsterdam, giving the urban designer a status within the spatial order of the Netherlands.[312] Articles published after the conference prove that urban design has become an independent field of study. Also the presence of people from 25 countries, including heroes like Unwin and Abercrombie, give the conference a high status.[313]

The ultimate association for urban designers is set up in 1935: the *Beroepsvereniging van Nederlandse Stedebouwkundigen en Planologen* (BNSP, Union of Dutch Urban Designers and Planners) to secure rights and wages. Emerging from engineering, by 1900 urban design is mainly connected to the worlds of architecture and housing, and in the 1930s economics, geography and landscaping are added to the curriculum. In the discussion about an independent urban design department within the College of Technology in Delft, it is made clear that the urban designers have to be in charge of the general design of the city, while calculating, construction and producing have to be left to the civil engineer. The urban designers have to be well informed about engineering (roads, bridges, railway, sluices, channels, rivers, polders, drained lakes and harbours), but in relation to city design.[314]

At the same time, many civil engineering students take classes at the Faculty of Architecture. When in the early 1920s urban design moves from engineering to social issues and a larger scale level, the mismatched boundary between the disciplines urban design and civil engineering becomes a fact.[315]

In the period that the discipline is liberated, different discussions with – and claims by – architecture and civil engineering arise. Architects are afraid that their artistic expression will be bound by the rules the urban designers will impose. But the common idea is that besides the aesthetic architects (busy with nice façades) and engineers (specialized in geodesy and mechanics) social engineers are necessary to handle questions about sewer systems and the water supply, the construction of schools and the improvement of labourers' dwellings.[316]

Independent Development

In the meantime, the urban designers philosophize about the city, stimulated by various groups of architects, such as *De Opbouw* (1920), *De 8* (1927), and the *Congrès Internationaux d'Architecture Moderne* or CIAM (1928). At several CIAM conferences, the functional city, containing a spatial division of functions, is discussed. The objective is to create light, air, and space in the city.

According to Webber and Rittel (1973) the industrial age, the idea of planning, in common with the idea of professionalism, is dominated by the

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[312] De Woningwet 1902-1929, 1-14
[313] Steenhuis 2009, 9 and 18
[314] Van Lohuizen 1942
[315] Calabrese 2004
[316] De Jong and Meyer 2000, 39

pervasive idea of efficiency. Drawn from eighteenth-century physics, classical economics and the principle of least-means, efficiency is seen as a condition in which a specified task can be performed with a low input of resources. This powerful idea becomes the guiding concept of civil engineering, and even though the disciplines are separating, it is also attached to the idea of cities. Urban design is seen as a process of designing problem-solutions that might be installed and operated cheaply.[317]

Because it is fairly easy to achieve consensus on the nature of problems during the early industrial period, the task can be assigned to the technically skilled, who in turn can be trusted to accomplish the simplified result.[318] This classic paradigm of science and engineering has underlain modern professionalism, but is not applicable to problems of open societal systems. Webber and Rittel:

> We shall want to suggest that the social professions are misled somewhere along the line onto assuming they can be applied scientists – that they can solve problems in the way scientists can solve their sorts of problems.[319]

Webber and Rittel define problems scientists deal with as 'tame' ones, the problem is clear and it is obvious when the problem is solved. The urban designer deals with open societal systems and therefore 'wicked' problems, which in contrast have no clarifying traits.

It is interesting for this story that Webber and Rittel make the connection to the military systems- approach, since that is one of the foundations of the discipline urban design:

> The classical systems-approach of the military and the space programmes is based on the assumption that a planning project can be organised into distinct Phases: 'understand the problem or the mission', 'gather information', 'analyse the information', 'synthesize information and wait for the creative leap', 'work out solution' or the like. For wicked problems, however, this type of scheme does not work. One cannot understand the problem without knowing about its context . . .[320]

What is fascinating about this perspective is that the master of Dutch modern urban design Cornelis van Eesteren is the designer of the General Expansion Plan for Amsterdam (AUP, 1934), which fits perfectly into this scientific approach, while at the same time he places high emphasis on the (hydrologic) context because it has so much impact on the design of the city.

Van Eesteren states in his explanation to the plan that

> . . . everything is controlled by the level of filling : the layout of the waterway system, the water storage surface, the sluice system, and pumping stations. A city laid out as an outlet waterway city must be

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[317] Webber and Rittel 1973, 158
[318] Webber and Rittel 1973, 158
[319] Webber and Rittel 1973, 160
[320] Webber and Rittel 1973, 160

designed differently than a polder city that lowered its groundwater table.[321]

The lower-level polder city is to be connected to the outlet water level of the *Grachtengordel* of Amsterdam. Van Eesteren mainly considers the connection of the road and water system as a complex design assignment (as in all the later designs of the area [car] mobility is the primary starting point). The ongoing roads need to be connected by means of slopes, canals need to be connected by means of sluices, and a solution has to be found to refresh the lower-level water.

The person of Van Eesteren, an architect who approached his assignments scientifically, is the third example of an urban engineer after Stevin and Rose: aware of the influence of hydrology on the realization of an urban vision.

The Chair of Urban Design

The establishment of a chair at the university is recognition in the academic domain and the start of developing a body of knowledge that the world of practice can build on. In 1904 the members of parliament have already discussed the installation of an urban design chair at the Faculty of Architecture in Delft. The urban designer shall be skilled in many ways, an architect with a broad scope on the future, and artist and definitely not an engineer, surveyor or a theoretical type. But in 1913, advised by the Society for Architecture, they decide that it is not necessary.[322]

The first year that urban design is on the curriculum at the Faculty of Architecture is in the year 1919. Architecture professor J.A.G. van der Steur (1865-1945) teaches the course ‘The aesthetic principles of city building’ in the fifth year. In 1924 M.J. Granpré Molière (1883-1972) adds to this ‘The general principles of city building’. From 1937 the courses are combined and named Urban Design.[323]

Different intensive courses (of a few days) in urban design are organized before and during the war. The last one is representative of the direction of the new courses to be set up after the war. J.P. Fockema Andreae is responsible for the legal conditions in urban design, history of building is given by prof. D.F. Slothouwer, Granpré Molière teaches the general principles, polders are taught by prof. ir. J.W. Thierry, landscape and agriculture by Bijhouwer, demographics, soil, business and housing by Van Lohuizen, road and traffic by Van Wisselingh and Froger, urban design by Froger and survey by Schermerhorn. Building-site preparation is not a specific course but it is probable that in the course on polders some tuition is given about building in wet and soft soils.[324]

Finally, after some lobbying, especially by Molière, in 1947 two chairs of urban design are installed at the Faculty of Architecture, Delft College of Technology. One is dedicated to design and one to research, filled respectively by J.H. Froger (1920-1976) and Th.K. van Lohuizen (1890-1956). Froger holds his inaugural speech ‘Het domein van de stedebouw’ (The

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[321] Van Eesteren 1934, 159
[322] Hoogenberk 1980, 153; Bouwkundig weekblad 1904, 140; 1914, 11
[323] Steenhuis 2009, 60
[324] Steenhuis 2009, 23

domain of urban design) on 1 October 1947 and defines the term *stedebouw* as city building and *stedebouw* (*stede* is *plaats* = place) as beautification of place which can be in the city but also in the countryside. The polders in this vision are urban design on a large scale. The detailing of a city or a polder, with its dikes, ditches, trees and green structures, which make the spatial diversification of the landscape, is also urban design.

Froger considers the nineteenth century expansion of the cities outside the fortifications as urbanism on the wrong track. Growing individualism, impressionism, strict values of good and clean, spiritual degeneration and weak governance are the guilty factors. In the twentieth century urban design is supported by the survey of soil conditions, present and past demands, development trends and prognoses. The aim of urban design is to be the reflection of the values of the culture that it represents. The survey results in the programme of development and the urban design in the visualization of the concept. Garden and landscape architects take care of the natural elements, engineers of the technical details and architects of the buildings. According to Froger, urban plans made from 1927 to 1947 are so detailed that nothing is left for the architects to do.[325]

Van Lohuizen reflects on the relation between urban design and urban research in his inaugural speech ‘De eenzaamheid van het stedebouwkundig werk’ (The loneliness of urbanism).[326] Van Lohuizen sees questions about the external and internal harmony, beautiful shape and size, situation, character (as expression of architectural proportions and as social organism) answered thought sophisticated socioeconomic and demographic survey. Survey is seen not as a calculation but as the product of the synergy between intuition and knowledge that gives deep insights that lead to the urban shape. This cannot be done by one person, this synthesis between aesthetic, technical, socioeconomic and physiological factors, but is the product of the cooperation between a designer and a researcher. The new education of urban design is meant, according to Van Lohuizen, for the architect and the civil engineer. [327]

In 1948 Cornelis van Eesteren (1897-1988) becomes the practice chair of urban design as an exceptional professor in the Department of Urbanism. His inaugural speech is called ‘De conceptie van onze hedendaagse nederzettingen en cultuurlandschappen, hun verschijningsvormen en uitdrukkingen’ (The conception of our modern settlements and culture landscapes, their manifestation and expression). Urban design is the means to design landscapes, cities and villages. Urban designers study the existence and the influence of shapes, urban design is the interaction between science and intuition.[328]

> We have no or little control over the origin of the natural circumstances that influences the shapes and expressions of our cities and culture landscapes, like the soil conditions, geological structure of the landscape. It will be fascinating and instructive to study the interaction between natural circumstances, (not in the least to our practise of urban design)

[325] Froger 1947, 1-16
[326] Van Lohuizen 1948, 1-9
[327] Van Lohuizen 1948, 1-9
[328] Van Eesteren 1948

> like the situation below MSL of the larger part of the Netherlands and the drive of human beings to control forces of nature to make this beneficial to their wellbeing.[329]

Interestingly enough, in the course of this study he continues: 'This will take us too far from the subject of this speech.' In his speech he talks about how urbanism is responsible for the content and shape of city and landscape, since both are the work of humans (in the Netherlands). The project of the urban designer is scientific and technical by nature and must be handled in time and space. The means of urban design have always been dependent on the state of technology and in interrelation with social needs. The development of society is attached to technological progress, new social needs appear with new technology and the negative effects always affect society. Then new development is necessary to deal with the negative effects. Van Eesteren sees industrialization as the reason that visual instincts are lost.

> Machines and industry destroy the essential structure of landscapes and settlements. The spatial disorder, in which we live, is an unavoidable consequence of a world that, like always, and now because of accelerating speed very obviously, is changing. I am convinced that the order will return. It will occur from the nature of things and their deeper meaning of that, both will be recognized, experienced so that they can be expressed in all human work and urban design.[330]

Then he refers to Hilbersheim and his publication *The New City* where the message is that the disorder can only be brought to order when all forces, past and present, that influence the origin and development of settlements are studied.[331]

He makes the strong connection between urban design and technology and feels that no aesthetic problem can be solved without systematic thinking and no technical problem without fantasy.[332] Construction is also aesthetic because mind and intuition are one, as Lao-Tse in Tao Te King says: 'Make your mind one with your intuition and let there be no conflict.'[333]

Cornelis van Eesteren, who is also a member of De Stijl and chairman of CIAM, works together with Th.K. van Lohuizen (who introduces social science and the survey) on the AUP. They both believe in modern urbanism, in which the city shape can influence the shape of society, the city shape is the expression of the spirit of the time and the realities of Modern Periods. The science of urban design investigates the functions and aims and the art of urban design enables the combination with elements like water, green and height differences in a spatial plan. The investigation plus the art together determine the shape and expression.[334]

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329 Van Eesteren 1948, 7
330 Van Eesteren 1948, 8-9
331 Hilbersheimer 1944
332 Van Eesteren 1948, 31
333 Van Eesteren 1948, 19
334 Vanstiphout 2005, 163

Both Froger and Van Lohuizen thank Granpré Molière, who is professor and stimulator of the new chair at the faculty, and Van Lohuizen and Van Eesteren also the Faculty of Civil Engineering, department of road and water construction, emphasizing their cooperation. The new course for urban design is set up for students of architecture, civil engineering or agricultural engineering.[335] The relationship between the Faculties of Architecture and Civil Engineering is very good since the independence of architecture in 1905. Many courses and teachers are common to both faculties.[336] Therefore it is not surprising that all three professors see a connection with the soil conditions and promote this through the survey, necessary to make well thought-through plans, connecting strongly to their practices and work in Amsterdam.

After the war the technical courses for architecture, and also in the new urbanism track, are cut back drastically to the minimum of what is necessary to enable discussions with constructors. This is of course the blueprint of what happens in the practice of building as well: division of the disciplines urban (and architectural) design and engineering. Between 1952 and 1964 the work of the students all show modernist designs for tabulae rasae: high buildings in parks.[337]

From 1969, with the new landscape professor architect Frans Maas, a new direction is established. Landscape becomes an important starting point for urban plans. Maas hires ecologist Chris van Leeuwen for more education in the natural system. His classes are very popular because the urban designers are eager to find new inspiration after the era of 'stamp' urban design on tabulae rasae. Ecology as replacement of the tabula rasa brings a completely new type of urban design and leads to the new SOM (StadsOntwerpenMilieu, Urban design and environment) group at the Faculty of Architecture of the university in 1977.[338] The initiator of this group, Kees Duijvestein, becomes one of the first professors of the chair of environmental design established in 1991; showing that the environment has finally impacted the institutional side of spatial development.

In the period 1959-1993 most of the research is done in separate institutes in the Faculty of Architecture. The *Instituut voor Stedebouwkundig Onderzoek* (ISO, Institute of Urban Research) starts in 1959 and is combined from 1986 with the *Centrum voor Architectuur Onderzoek* (Centre of Architectural Research, 1964) forming the *Onderzoeksinstituut voor Stedebouw, Planologie en Architectuur* (OSPA, Research Institute for Urbanism, Planning and Architecture).[339]

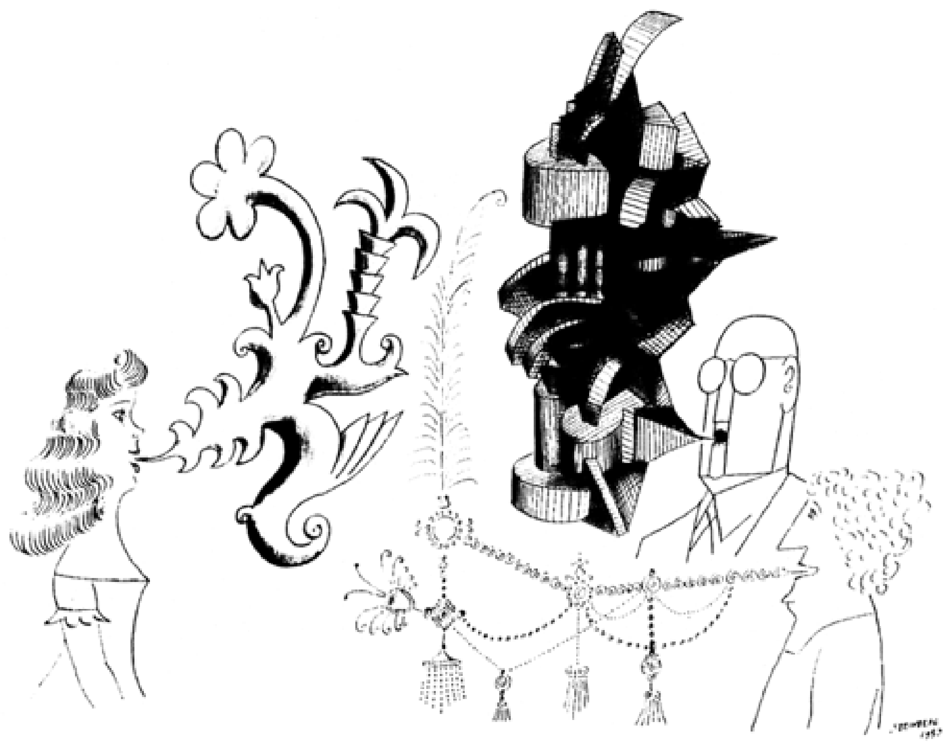
The research tradition at the Faculty of Architecture is not founded in solid science due to the fact that in architecture ideals and intuition are expressed in aesthetics. The first more serious research initiatives are taken by prof.ir. Th.K.van Lohuizen. He emphasizes a strong relation between

[335] Steenhuis 2009, 39
[336] Steenhuis 2009, 12
[337] Steenhuis 2009, 50
[338] Steenhuis 2009, 55
[339] Den Draak 2001,107

design and research in urbanism to create a specific representation of the field.[340]

His successor drs. C.S. Kruijt creates the ISO in 1959 and there urban designers work together with civil engineers. Half way the 1960s ir.L.H.J. Angenot becomes professor Urban Research and also director of ISO. Angenot is a civil engineer and in the line of Van Lohuizen steers onto scientific research methods as foundation of the urban designs.[341]

In the 1970s and 1980s most research is done into living in expansion areas, living in high densities, effects of the increasing leisure time, planning of shopping facilities, wind and noise disturbance. All research must offer building stones for the disciplines of urban design and planning.[342] In 1993 the OSPA is closed because of negative critique of the output that is made by several committees since 1989.[343]



Picture 5.1 Architectural ideals and intuitions are expressed through aesthetics.
Source: Steinberg 1959, in: Draak 2001

Post-War Urbanism

After the Second World War the city expansions are first situated, second the soil and the water systems are investigated and third the civil and culture technical interventions determined to improve the soil conditions. Weak soils are strengthened with sand in the fourth instance, calculations for foundation piles are made in the fifth and in the sixth measures are taken

[340] Den Draak 2001,108
[341] Den Draak 2001,112
[342] Den Draak 2001,116
[343] Den Draak 2001,121

for the discharge and drainage of the built area.[344] In his inaugural speech on 12 November 1975 titled 'Spel met water, grond en land' (Game with water, soil and land), W.A. Segeren, extraordinary professor in water construction (polders) recognizes this loss of a direct relation between the location of the settlement, the way of life and the surroundings.

Urban designs can be uniform on any soil condition due to the technology of building-site preparation: the spouting up of a layer of sand. There is no incentive for the urban design to react to specific conditions, because all conditions become the same. At the same time urban design is influenced by industrial building, the production of standard apartment buildings and ground-bound houses used everywhere. These two standardizations are also detrimental to the characteristic locality of urban expansions.[345]

Thus industrialization, the division between technology and design and the further specialization break up the urban structure into independent, interwoven networks of infrastructure, housing, public space and nature: all disconnected from the landscape conditions. In the *Grachtengordel* and the *Waterproject* all these networks together orchestrated the urban ensemble, now the main structuring element is (auto)mobility.[346] Civil engineers solve the water issues in such a fashion that the urban designer never even knows that they have been dealt with. Technological progress, such as improved pumps and better calculation methods, make the preparation of a larger site possible by filling it with sand. This means that in combination with an underground drainage system, significantly less surface water is needed.

In the end the urban designer considers water a waste product, to be situated underground or on the outskirts of districts or integrated into the infrastructure or the green space system. The network structure of the water system as designed by civil engineers cannot be recognized as such, since underground pipelines alternate with the surface water. Legibility of the water system disappears in the 1960s.

Introducing Landscaping in the 1970s

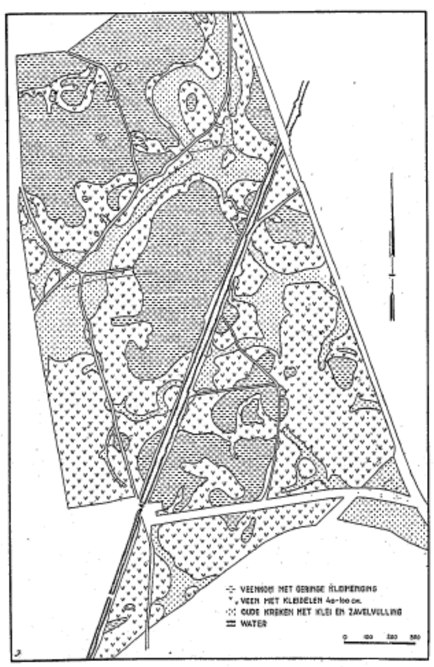
Webber and Rittel mark the change, the end of the idea of efficiency, at the end of the 1970s when the urban context is reintroduced. In response to the technocratic approach to urban design in the 1950s, it is in the 1970s that the ecology of water returns to the attention of the urban designer. Already by the end of the 1960s some developments put ecology and the landscape on the agenda of Dutch spatial planning. The exhaustibility of fossil fuels becomes part of the human consciousness through the oil crisis (1973) and the Club of Rome (1972) sheds light on the influence of humans on natural systems. Ecology becomes important within spatial planning and the notion of integral water management is brought up.[347] From then on it is assumed that ground and surface water must be managed in a physical sense as well-founded coherent systems (physically, chemically and biologically). Integral water management means a shift in regime for civil engineering. It leads to new objectives requiring new designs and working methods. It also means a

[344] Segeren 1975, 7-9
[345] Segeren 1975, 11
[346] The developments after World War 2 are accurately analysed by Van Eijk 2002
[347] Van Leeuwen 1965, 1966, 17

strategic regrouping, as together with civil engineers, biologists and ecologists have also become players in the field.[348]

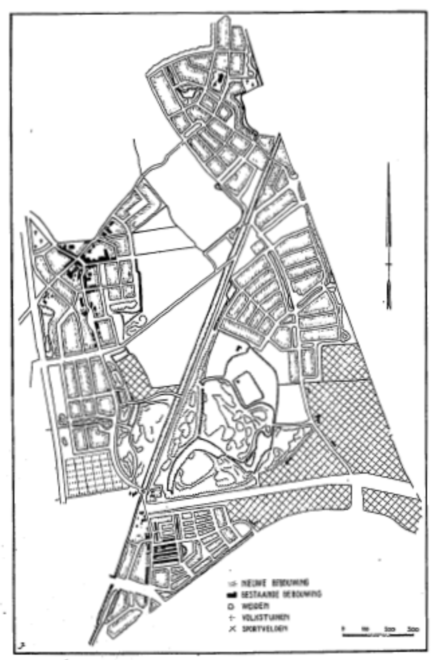
At the beginning of the 1970s the landscape architect liberates into a mature and qualified expert with specific assignments. After the Second World War at the University in Wageningen, the new chair of landscape architecture is taken in by prof. dr. ir. J.T.P. Bijhouwer. Before the Second World War garden architects could follow a course in Wageningen (that starts in 1890 with garden architect Leonard Springer), study in Boskoop (from 1898), the girls school Huis te Lande (Rijswijk) or abroad as, for example, did Mien Ruijs.[349]

Bijhouwer is basically responsible for the first group of landscape architects that graduate and change the appearance of the Netherlands in the post-war years. The great challenges are infrastructure, city expansions, nature, re-allotment, recreation and the traditional project of private gardens.[350] The introduction of the landscape architect in urban design means that the landscape enters the city. Also the separation of functions (infrastructure, housing and green structures) of the post-war era is interchanged for integration. Urban designers, landscape architects and architects together design the city and new notions like morphology of the soil conditions come into use.



Kaart 1. Bodemkaart van Kethel en omgeving

Map 1. Soilmap of the village of Kethel (north of Schiedam)
Legend: 1. Peat. 2. Peat with clay. 3. Clay and sandy clay (old creeks). 4. Water.



Kaart 2. Bebouwingsplan voor Kethel en omgeving

Map 2. Townplanning map of the village of Kethel
Legend: 1. New planned houses. 2. Existing buildings. 3. Pasture land. 4. Allotment gardens. 5. Playing-grounds

Picture 5.2 Left the soil map of Kethel area, left the urban design on the base of the soil map. Source: Bijhouwer 1947

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348 Schot 1998, 63 and 181-192
349 Steenhuis 2009, 232 and 354
350 Steenhuis 2009, 5

Bijhouwer publishes this notion of basing an urban plan on soil conditions as early as 1947: 'Een bodemkartering ten behoeve van stedebouw' (A soil survey on Behalf of Town-Planning').[351] In this article he describes how they chose the location between Kethel and North Kethel for a garden city in Schiedam. North Kethel will probably in the future become a train station and Kethel is going to be connected to the provincial road from Schiedam to Delft. The summary of the article sums up Bijhouwer's point:

> A soil survey is made for the town-planning of Schiedam, where a suburb is to be built north of the old town. The area chosen turned out to be low, peaty land which has shrunk several yards due to deep drainage. Old creeks, filled with sand, have not shrunk and now form high ridges in the low peat land. Along these creeks the peat has been covered or mixed with clay improving the carrying-capacity of the soil. The roads have been projected on the old creeks and the low peaty grounds will not be used for the building of roads or houses. The plan of the suburb shows a true resemblance with the soil map.[352]

Bijhouwer invites prof. dr. ir. C.H. Edelman, professor of soil mechanics in Wageningen, to make a study of the soil conditions of the location between Kethel and North Kethel to enable them to anticipate these conditions. Bijhouwer writes that Edelman accepts this assignment gratefully because there is not much known about the area. The result is interesting. They not only chart the characteristics on which the buildings, roads, sports facilities, public gardens, park, water courses and grass land could be planned, they also find an old settlement on a artificial dwelling mound and old creeks. Bijhouwer appreciates the plan for the garden city because the given conditions have formed the urban design. That will never occur when the personal design preferences of the urban designer only are followed.

The park that is planned on the thinnest clay layers and the softest areas of peat is meant to be grassland. Bijhouwer even mentions that cows needed for the milk supply for the city can be kept here! These grasslands are built on today, however, probably on a layer of sand. The park, the sports facilities and the public gardens still exist. Some of the planned garden city has been built but most is from a later date.

[351] Bijhouwer 1947, 36-38
[352] Bijhouwer 1947, 36-38

Picture 5.3 Current situation of the Kethel area.
Source: Google Earth

In 1975 Segeren recognizes the increase of attention for ecology. Uniformity between 1950 and 1975 is not only caused by the neglect of the soil conditions and the water system and industrial building methods; the spirit of the time also played a crucial part. Urban designers anno 1975 try to distance themselves from straight patterns and use more natural forms with differentiation in the façades, forming little squares that are less organized. They incorporate the existing natural structures (trees, streams, ditches, landscape structure) and sometimes even use the soil conditions as the basis of the design. The development of different methods of building-site preparation like partial heightening is an illustration of this. Segeren wonders in his inaugural speech if that is enough, or is it impossible to bring the creative disciplines and the engineers together?

Another point Segeren makes is that the knowledge about water in the countryside is gathered in state water maps, data of the Water Boards and state department water, the groundwater level archive of TNO (Organisation for Applied Scientific Research) and groundwater classification maps with foundation soil surveys. However, for urban areas there is no systematic organization of data and this knowledge is necessary to better attune land use to the natural suitability of the site and the integration of different uses.[353]

The prelude to the Phase of Adaptive Manipulation that takes flight in the 1990s is characterized by the professionalization and gradual domination of landscape architects in urban design. Frits Palmboom's 1987 publication *Verstedelijkt Landschap* (Urbanized Landscapes) is an important step in absorbing landscape features into the urban tissue: Landscape Urbanism.[354] The work by H+N+S Landscape Architects and their contribution to the Plan *Ooievaar* (1986, plan stork) introduced the term 'casco approach' to landscape planning. This approach assumes that various spatial functions are grouped on the basis of their development rate and result in a spatial framework for the longer term, in which zoning is replaced by principles for change.[355] Together these offices, Palmout Urban Landscapes and H+N+S Landscape Architects, design many urban plans in which the landscape plays a dominant role.

Building-Site Preparation

An article in *De Ingenieur*, about central heating in New York by means of steam, describes the change towards the modern city:

> The difference between life in the modern city in comparison with before is that it is dominated by the reduction of working hours and the rush to build up new facilities. Railways, telegraph and telephone becomes essential in our working force. Water and light networks are expanding and it probably won't be the only network, also power will be transported via different routes and soon our houses will be equipped like working places, with all facilities of industrialization. This concept of a city wherein the citizens can provide themselves instantly with light, heat and water and can connect to the whole world, seems to please the Americans.[356]

The combustion engine, electricity and the development of soil mechanics at the beginning of the twentieth century are the changing forces of the Manipulative era. Besides the shifting sources of power (from steam to diesel, oil, gas, electricity) also the engineering discipline becomes differentiated. At the beginning of the twentieth century *De Ingenieur* offers special appendices for the different specialists. Around the 1930s these are all eliminated because some now have their own journals and *De Ingenieur* is becoming too differentiated.

Improvements in scientific research during the Manipulative era add to the development of better and more refined ways of dealing with water, soil and construction. The acceleration of powers ensures that all can be realized

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[353] Segeren 1975, 12-29
[354] The publication is part of the case in chapter 5c, the accelerating flower power.
[355] Nienhuis 2005, 121
[356] *De Ingenieur* (1888), 18 - 19

on a scale that becomes larger during the century. The control over things and water becomes absolute: manipulation.

In the former chapter the seven fields of knowledge connected to the building of cities on wet and instable soil are defined: engine power, important for the movement of soil and water, the building and production industry; general water management, considering larger water systems; soil mechanics, which studies the characteristics of soil; soil improvement, which combines soil mechanics and engine power; hydrogeology, the flow of groundwater; pile foundations and, seventh, the field of drainage systems (including sewer systems). In this era all these fields develop and it is important to take notice of what happens during this Phase. Soil improvement, pile foundations and drainage systems make a start in this chapter.

I Engine Power

In essence, the transformation to the new combustion engine power and electrical power is comparable to the increase in scale and intensity that comes with the transition to steam in the former chapter. First difficulties with purchase and maintenance of the new machines that take time to be integrated into the industry are the reason for the steam engine being introduced slowly; the same goes for the induction engine and electricity. The greatest advantage over the steam engine is that the size and the maintenance of the new engines have shrunk. The engines are smaller and easier to work with. Different study trips are taken to the USA, where the induction engine is introduced much earlier, for example machines used in irrigation projects. Different types of machines are used there to dig ditches and move ground.[357]

The first electrical driver of foundation piles is taken into use in 1911 by the firm ADR Bakker when building the Amsterdam-Rhine channel. The difference from the steam driver is that the motor continues to rotate and is disconnected but not stopped, as with the steam driver, just before the block falls. The advances are that the machine is much smaller and therefore can be run by fewer people. Moreover the pile driver can also be used as a crane.[358]

Besides dry movement of ground at the end of the nineteenth century a new wet method is developed in spouting up sand. This method can be used for two goals; first the removal of soil, in the case of deepening channels and rivers; second for filling to prepare a site for building. The first time this method is used is for the building of a rail dike in the Dutch colony of Indonesia in 1882-1883. Via ditches and a wooden spout tube on bamboo constructions, the water with sand is spouted through. When the sandy water reaches its place of destination, the to-be-raised area, it is slowed down by bamboo fences or little dikes to let the sand settle.[359]

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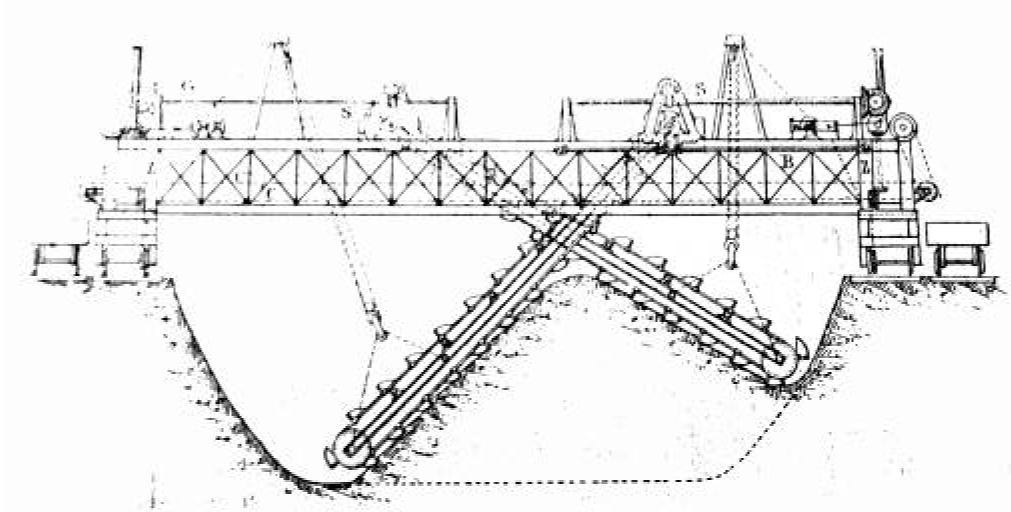
[357] *De Ingenieur* 26 (1910), 480
[358] *De Ingenieur* 16 (1912), 337
[359] Wijnmalen 1899-1900



Picture 5.4 Excavator by Adolph Vogt, ca. 1888
Source: *De Ingenieur* 1910

This method improves with the invention of the sand pump at the end of the nineteenth century. It can pump sandy water 8 to 10 m high and over a length of 350 to 400 m.[360] This means a scale enlargement in building-site preparation that is gratefully used in the huge building project after the Second World War. This also creates a certain independency of the subsurface, as the autonomous sand layer is cheaper to produce. However, technically, the method is not optimal because the pipes clog and can break. Also the fact that the sand has to go through the sand pump does not help the process.

P.A. Bos, contractor of Public Works in Gorinchem, solves this problem with J. & W. Smit in Kinderdijk with the design of a machine that pumps the sand from the buckets to the centrifugal pump that also sucks up water via the bottom of the ship. The watery sand goes through the pipes and before blockage can happen and the pipes break, the system automatically stops.[361]

In the Netherlands the moving of ground is usually done by dragline and rail. The allied forces bring much larger and more advanced machines with them after the Second World War. The need for large numbers of dwellings together with the infrastructure formed an immense urban challange. Factors like economical use and manpower are reduced by the use of the new mechanical approach to moving ground.[362]

Until 1940 there is a conservative period in the use of dredgers characterized by the fact that even though the combustion engine breaks through in 1925, sand suckers keep on working with steam engines.

After the Second World War the progressive era starts. The loss of machines in the war and the huge challange of rebuilding the country force the change to diesel engines. The use of diesel has enormous consequences for the development of dredging machines and suckers also gain an increased capacity because of the use of diesel. For the sand pump, a pump

[360] *De Ingenieur* 10 (1899), 114
[361] Leemans 1887, 174 - 175
[362] *De Ingenieur* 28B (1946), 11 B98

with an open wheel (just like a centrifugal pump) and no house, the use of diesel means an innovation, already used for 40 years in the USA, with a closed wheel that increases the return of 55 per cent to much more. Also, the increase of the diesel engine means an increase of the pressure in the transportation tubes, so the sand can be transported further and can be taken from a deeper depth.[363]

After the Second World War the development of machines and pumps for a larger scale continues and research is done continuously. The Ground Movement chair is established on 18 January 1978 with professor dr. ir. J. de Koning. In his inaugural speech he states that ground movement is one of the oldest human activities and a crucial condition for good infrastructure and further urban development. The period of pioneering is from 1850 to 1900 when the machine took over manual labour. Between 1900 and 1950 the world of the inventors and the world of the users become separate.[364] The consequence of this is that developments are made on the basis of rapidly developing science and not on knowledge from experience. After 1950 this is put to profit in the large-scale expansions of the cities, preparing large areas so any city could be built. Engine power during the Manipulative era causes, as steam did, a scale enlargement in many sectors that continues till today. Building of large-scale infrastructure, scale enlargements in buildings, development of industrial materials come together in the post-war era when the Dutch are convinced that anything can be man-made.

II General Water Management

The developments in general water management that started in the former Phase accelerate, enlarge and become simultaneously more detailed. The organization and technical developments become refined and streamlined. Of course large-scale disasters that demand large-scale projects also help. For instance, the flood of the northern part of the Netherlands in 1916 leads to the building of the Afsluitdijk, closing the Zuyderzee from the Wadden and creating the IJsselmeer; the flooding of the south-western part of the Netherlands in 1953 leads to the famous Delta Works.

Due to new types of engine force the detailing of the general water management also becomes more and more refined and works on a smaller scale. Examples are the paddle wheel and the Archimedean screw being replaced by the centrifugal pump;[365] the improved hydraulic achievements in sluice and dam building by the application of reinforced and pre-stressed concrete; riveted and welded metal structures; electrification and rationalized building processes modernize the pumping, dredging and movement of sand and the design of quays, sluices and dams; and with lighter iron constructions building bridges in cities becomes easier, higher and more mobile, which benefits the urban infrastructure. All these details build up a sophisticated general water management sector.[366]

Advances are also made in the mathematical and hydraulics department. H.A. Lorentz, one of the Netherlands' greatest physicists,

[363] Van Wijngaarden (1962), W179-189
[364] *De Ingenieur* 6 (1978), 123
[365] *De Ingenieur* 27 (1914), 534
[366] Schot 1998, 178

develops a method to predict tidal movements. This method is of invaluable significance for hydrodynamic research in the Netherlands. Several innovations take place in the area of river and sea management: H.A. Lorentz develops a storm flood model between 1935 and 1939; in 1937 dr. ir. J. van Veen discovers that electrical current has the same characteristics as tidal flow; in 1939 ir. J.P. Wemelsfelder succeeds in proving a relationship, based on statistical calculations, between a storm surge and high water levels. During the period from 1930 to 1939 there is a consolidation of the achievements and a further development of hydraulic engineering techniques, based on model-based and mathematical analyses and prognoses.[367]

When computers appear in the 1980s, calculation models are favoured, as they can be done faster, and are also capable of handling complex problems. Technology is increasingly dominated by measurement, prognosis, calibration, verification and validation.

Social protests in the 1970s bring an end to the technocratic idyll of the Ministry of Transport. Under pressure from environmental technological quarters the construction of the last Zuyderzee reclamation, the Markerwaard, and the construction of the Oosterschelde Dam are stopped. The emphasis is then placed on further refinement of water management and improvement of water quality. Water quality is then placed on the agenda due to the pollution of the Veluwe Lake area and the Brielsemeer (1970). The Environmental Act is established.[368]

During the era of accelerating powers water management develops to a stage where the control becomes absolute. Large infrastructural works like polders, dams and dikes are carried out, again developing knowledge that can be reapplied. The rivers are tamed and the regional water system can be drained and pumped if not hidden under a layer of sand. The general conditions of water management make it possible to build any city anywhere without the primary concern of flooding by river and sea. At the end of the era the influence of technology on the natural systems comes under debate and the first steps towards finding a new balance are taken.

III Soil Mechanics

One of the first new facts in the field of soil mechanics in the Manipulative Phase is the discovery of Charles Robert Darwin (1809-1882) that resistance increases with the density of sand. A few years later Osborne Reynolds (1842-1912) reveals the dilatancy of sand. Reynolds states in 1885 that the recognition of this property of dilatancy will, from a practical point of view, place the theory of earth-pressures on a true foundation, but that ‘the greatest results are likely to follow in philosophy, and it is with a view to these results that the investigation is undertaken’. He goes on to declare that:

> . . . the recognition of this property of dilatancy places a hitherto unrecognized mechanical contrivance at the command of those who will explain the fundamental arrangement of the Universe, and one which, so

[367] Schot 1998, 168-188
[368] Dubbelman 1999, 156-158

> far as I have been able to look into it, seems to promise great things, besides possessing the inherent advantage of extreme simplicity.[369]

Both Darwin and Reynolds conduct their research in relation to social aspects of technology.

The development of soil mechanics starts at the beginning of the twentieth century. The need for the analysis of the behaviour of soils is present in many countries, often as a result of spectacular accidents, such as landslides and building foundation failures. In the Netherlands the slide of a railway embankment near Beek-Elsloo in 1892 is the first incident that brings about the discussion. Geologists believe the dike is situated on the wrong soil conditions and civil engineers figure it needs more enforcement. The dike is removed, a hole is dug down to the more stable sub-soil and a new dike is constructed. Added to a new drainage system of ditches, drain pipes and tubes, the new dike proves to be stable.[370]

Again in 1918 a railway embankment slide near Weesp brings about an intense discussion and *De Ingenieur* is full of the incident, the causes and the solutions for sliding dikes. The issue is indicative of the urgency of developing more knowledge of soil mechanics. In one article 15 hypotheses are discussed as to the possible cause of the sliding dike, all solutions show the insecurity and lack of knowledge of soil mechanics.[371]

This disaster also leads to the first systematic investigation in the field of soil mechanics by a special commission set up by the government. The commission cannot agree on the cause of the accident that cost 41 casualties; it becomes painfully clear that the science of soil mechanics is not yet ready for large-scale engineering. Even though many of the basic principles of soil mechanics are well known at that time, their combination into an engineering discipline has not yet been completed.[372] Important pioneering contributions to the development of soil mechanics are made by Karl von Terzaghi (1883-1963), who, among many other things, describes how to deal with the influence of the pressures of the pore water on the behaviour of soils. He starts modern soil mechanics with his theories of consolidation, lateral earth pressures, bearing capacity, and stability.

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[369] Reynolds 1895, 133
[370] De Vet 1994, 10
[371] *De Ingenieur* 44 (1919), 813
[372] Verruit 2001, 7

Picture 5.5 In 1918 a railway embankment slide near Weesp brings about an intense discussion. Source: Verruit 2001

This is an essential element of soil mechanics theory. Mistakes in this aspect often lead to large disasters, such as the slide near Weesp. The committee that investigates the disaster near Weesp concludes that the water levels in the railway embankment have risen because of sustained rainfall, and that these high water pressures are too high for the embankment to cope with.[373]

In the Netherlands much pioneering work is done by Albert Sybrandus Keverling Buisman (1890-1944), especially on the deformation rates of clay. In 1919 he is installed as professor in mechanics at the University of Delft and starts his research into soil mechanics.

From then on the different developments happen in rapid succession. In 1920 a commission to study the load-bearing capacity of soil is installed as part of the Bouw- en Waterbouwkunde (construction and hydraulics) department of the KIVI (Royal Institute of Engineers). The commission, made

[373] Verruit 2001, 7

up of important men like Cornelis Lely (engineer and statesman responsible for closing the Zuyderzee and building new polders in the IJsselmeer) and Keverling Buisman, starts with an inventory of existing knowledge and writes to 1747 technicians with a questionnaire about research into the load-bearing capacity of soil, directions in local building regulations and other standards. Over two-thirds of the people questioned think soil mechanics research is a waste of time and no one uses the same standards.[374]

Picture 5.6. Laboratory for Soil Mechanics
Source: Verruit 2001

On 14 February 1934 in Delft, the *Laboratorium voor Grondmechanica* (LGM, Laboratory for Soil Mechanics) is set up as an independent part of the *Stichting Waterbouwkundig Laboratorium* (Hydraulic Laboratory Foundation). Until 1960 soil mechanics research and advisory activities are concentrated in the LGM and the municipal departments of Rotterdam and Amsterdam. Many great assignments are arranged by these municipalities; Rotterdam has the first, with research for building the Maastunnel (1934) that leads to the very first plan for a foundation that is adjusted to local variations and the type of soil on site.
The invention of spouting up sand means a significant scale enlargement that, at the beginning of the twentieth century, comes precisely at the right time: just when building practice is becoming industrialized and municipalities are obligated by the Housing Act (1901) to draw up expansion plans. Organizations also responded to these developments, for example the Royal Society of Engineers (KIVI) installs a department of soil mechanics in 1949. Rotterdam is probably the first city to apply the new technology. The city continues its progressive attitude when in 1946 the director of public works G. Plantema opens the department of soil mechanics in Rotterdam. This department will supply the necessary information about the characteristics and the behaviour of soil to the departments of water construction, harbour works and urban design. New devices are invented

[374] De Vet 1994, 13

here, such as the deep probe machine, the electrical water tension meter and the soil pressure box.[375]

One of the fast-developing technical improvements takes place in 1935 with the constructed sounding-method, which measures the load-bearing capacity of soil layers at deep levels. Building on territories with inadequate and unknown soil conditions, wet and weak soils, is more and more common due to the great expansions of cities.

After 1960 more companies are founded as sounding becomes a regular procedure to produce a soil profile and a foundation plan.[376] But new developments keep coming from Rotterdam; the city on peat has great difficulties with buildings higher than six to ten storeys due to the soft soil. In 1978 the municipality wants to know what the possibilities are and a group of 'angry young men' go to the land of the high-rise: the USA. The solution is to not rest the foundation piles on the 12-m-deep sand layer but to sink them 50 m, to the second layer of sand. Since then high-rise is no longer an issue.

In 1961, geotechnical calculations are done for the first time, using the central computer at Delft College of Technology (named Zebra).[377] The development of instruments continues, for example the density meter (1973) geo-environment instruments (1987) and improved formulas for subsidence (1991, Den Haan). In many countries of the world there are similar institutes and consulting companies that specialize in soil mechanics. Usually they also deal with foundation engineering, which is concerned with the application of the principles of soil mechanics to the design and the construction of foundations in engineering practice. Soil mechanics and foundation engineering together are often designated as geotechnics.

The technology policy also changed. In 1980 the Ministry of Transport, Public Works & Water Management and the Department of Hydrological Engineering introduce guidelines for soil mechanics from the perspective of designers and constructors and thinking from the construction point of view. First the properties and characteristics of the soil at a site need to be determined through soil and subsurface investigation, then the foundation parameters need to be considered, tests should be done in the field and in the laboratory, culminating in a final calculation.[378]

The Manipulative Phase is very fruitful for the field of soil mechanics. The Phase started out knowing very little and ended with the discipline as a Dutch export product. This development of knowledge is crucial for building dikes, large infrastructural works and the building explosion on layers of sand after the Second World War. Soil mechanics in the Netherlands remains critical, especially for the adaptive Manipulative attitude towards the natural system.

IV Soil Improvement

Because weak clay soils have characteristics similar to those of liquids, impermeability and incompressibility, buildings are thus comparable with floating objects and stability can only be reached by foundation piles and

[375] Moscoviter 1996, 73-74
[376] De Vet 1994, 17
[377] De Vet 1994, 45
[378] *De Ingenieur* 28/29 (1980), 14

replacement of the clay with solid soils (soil improvement). At the end of the nineteenth century there is some knowledge about how this can be done and what the characteristics of clay mean for the building industry.[379]

Around 1900 the idea that weak clay is impermeable and incompressible is generally accepted. This type of soil is not reliable for a secure foundation, because it can be pushed aside like a fluid. Improvement can easily be done by removing the weak clay and adding sand. Different ideas and methods to improve soil by enhancing the permeability and the load-bearing capacity are developed.

An article by engineer Hackstroh in 1903 about the load-bearing capacity of sand supplementations on building sites describes in detail how to build a sand layer. He implies that building such sand layers is a relatively new phenomenon – especially because the article goes on to explain the influence of the groundwater level and the use of water in building the layer. The groundwater level is of importance because sites that are too wet turn the sand into a swamp. On the other hand, the use of water to stabilize the layer is much more effective than compressing the soil with heavy weights. The movement of the grains of sand by water makes them fit together more tightly and the pores are better filled than by forcing them with weight. According to the Author the sand slide in Beek-Elsloo is caused by a too high groundwater level that makes the soil unstable.[380]

Besides the fact that experience is lacking, calculations are not available either. The only method to test the strength of the raised ground or the load-bearing capacity of foundation piles is by actually testing with weight.[381]

In the 1920s it becomes common to raise expansion areas on the outskirts of the cities with sand or dredge sludge. The consequence of filling is that the roads are also built relatively high above groundwater level, especially in polder areas where the groundwater level is controlled. The water level will also be high in the newly raised land, which, being very wet, will be like a swamp. It will be impossible then to do the digging for building the foundation.

In a normal situation the ground is removed some distance under groundwater level and in the (drained) excavated area the foundation piles are driven in the ground and foundation walls are built. After the excavated area is heightened to street level the building can start. That is why in Amsterdam the social housing projects cannot be built, the dredge sludge is too wet and the grounds cannot be excavated. Engineer C. Slim and engineer P. Bergsma, of the municipal Department of Public Works of Amsterdam, provide a solution to this problem. The solution is a new type of foundation construction making it no longer necessary to excavate the site. By connecting the foundation piles to the floor foundation a kind of table – with more than four legs – is constructed that is very stable. To ensure that the wooden piles are beneath groundwater level the concrete framework of the floor foundation has to be of sufficient length. This method is cheaper and faster and is used in Amsterdam-Noord.[382]

Until 1940, building sites in Amsterdam are always raised above the

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[379] *De Ingenieur* 1 (1892), 4
[380] Hackstroh 1903, 193
[381] *De Ingenieur* 10 (1899), 114
[382] *De Ingenieur* 10 (1921), 184

level of the *boezem* (discharge outlet waterway). The expansions are not that large-scale because dwellings are placed in higher buildings. After the 1940s, the demand for ground-bound dwellings increases significantly; this together with the desired large green structures claims more space.[383]

In 1940 a new procedure to enhance the load-bearing capacity of the building site is introduced: vibroflotation. By vibrating the soil and pressing it together at the same time and injecting water, the soil density becomes higher. It is done for a government building in Nurnberg (Germany).[384] In 1955 the grounds under the old post office in The Hague are stabilized with the use of chemical soil improvement. This is done to prevent subsidence while building a new expansion next to the post office.

In the 1970s soil enforcement with Stabilenka tissue (Enka Glanzstoff) is introduced. This tissue is chemically proven to have a good permeability and improved the load-bearing capacity through the distribution of the weight and the compensation of subsidence differences.[385] And seven years later in 1977, freezing of the soil, used for temporary improvement of building sites while (re)constructing foundations, sewer or other constructions, is invented.[386]

Soil improvement in the Manipulative Phase takes enormous steps, like the former fields of knowledge that are strongly connected. The steps are taken away from the natural soil conditions towards making them fit for any type of urbanization.

V Hydrogeology

Very little is known about groundwater flows at the end of the nineteenth century.[387] In the last decade of the century F.E.L. van Veeren publishes different articles about the flow of groundwater in *De Ingenieur*.[388] The idea that the water system is all interconnected has his special interest. According to Veeren, the research of Gümbel, Niedermeijer, Pettenkorfer, Delesse, Suess, and others into the flow of the Isar, Donau, Theiss, Lunnat, Siene and Aa proves that groundwater flows to the river; the greater the distance from the river the higher the groundwater level. This is unknown until that time.

In the Netherlands the knowledge about groundwater flows comes about when building the urban drinking water supply systems. The ground works are extensive and often the excavated sites show flow of water, groundwater. Different researches start because the direction of the flow is also of great importance for the urban drinking water systems. For example, the flow of groundwater near cemeteries cannot be connected to a flow that is captured for drinking water. Also, in expansion areas it is important to take the direction of the groundwater flow into consideration when planning the streets and the buildings, especially when situating cesspits and wells, which need to be separated.[389]

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[383] *De Ingenieur* 21 (1958), B99
[384] *De Ingenieur* 12 (1940), B69
[385] *De Ingenieur* 40 (1976), 791
[386] *De Ingenieur* 47 (1977), 910
[387] *De Ingenieur* (1890), 209
[388] Tijdschrift van het Koninklijk Nederlandsch aardrijkskundig genootschap (1892, 1893, 1897, 1904), *De Ingenieur*, en op het Vierde Nederlandsch Natuur- en Geneeskundig Congres z.d.
[389] Veeren 1896, 43, 47; 1897, 318

Engineer Penninck also publishes various articles in *De Ingenieur* about the flow of groundwater. He starts his research in 1889 and in 1905 he proves by calculating the flow of groundwater that all that is understood about the flow is wrong. Until then the general understanding is that the flow of groundwater in an area next to a river is separated from the water flow in the river. Different tests confirm his suspicion that both flows are interconnected and the hydrological gradient forms one system.[390]

Groundwater research is important for the draining of polders, seepage, preparing building sites in relation to water nuisance, subsidence and drought. Understanding the phenomenon of seepage makes a crucial development with the building of the Zuiderzee polders. The reason for seepage is a pressure difference between upper and lower groundwater levels, discovered by ir. V.J.P. de Blocq van Kuffeler (1878-1963) and published in his Wieringermeerrapport (1914) and report '*Staatscommissie tot het instellen van een onderzoek omtrent het vraagstuk der droogmaking van de plassen beoosten de Vecht'* (State Commission that does research into the pumping dry of the lakes east of the river Vecht) (1920).

Another stimulus for the research in groundwater flows is the rail accident in Weesp (1918), described in a former paragraph. The cause is the change in rainwater flow in the dike, so the role of water pressure in the soil is recognized as an important factor in the load-bearing capacity of grounds.

The first contact between engineers in water management and engineers studying groundwater mechanics is in the construction of the Noorder sluice in IJmuiden. For building the sluice the site has to be dry. In another project in 1880 the pumping of the surface water to make the site dry resulted in a landslide. The designing engineer dr. ir. J.A. Ringers (later Minister of Reconstruction after the Second World War) introduces the geohydraulic engineers to the project in 1922. They undertake pre-research and make a recommendation for the way to proceed in building the sluice. Instead of pumping away the surface water they suggest pumping the source, the groundwater flow. The pilot project is the sewer built in The Hague in 1898. After this project many more co-operations follow, of which the largest is the Zuyderzee polders. To keep the new polders dry they have to be permanently pumped free of water, which turns out to be damaging to the geohydrologic balance in the bordering old land and to the position of the boundary between salt and fresh water.[391]

J. Versluy received his doctorate in 1916 in Delft with his dissertation 'De capillaire stroming in de grond' (The capillary movements in the ground), which is the start of the research into the movement of groundwater. Different articles in *De Ingenieur* and geohydraulic dissertations prove the interest this subject has for civil engineers: dr. ir. J. de Glee in 1930 'Stroming van groundwater rondom boringen' (Movement of groundwater when digging holes), dr. ir. J.H. Steggewentz in 1933 'De invloed van getijden van zee en rivier op het stijgen van grondwater' (The influence of tidal movements of sea and river on the rising of groundwater), dr. ir. P.C. Lindenbergh in 1941 'Management van Duinwater' (Management of dune

[390] Penninck 1905, 482
[391] See: Van der Steen van Ommeren 1903, 289, Schot 1998, 167, Arends 1994

water), and dr. ir. J.H. Edelman in 1947 'Berekenen van grondwater stromen' (Calculating groundwater movement).
The agriculture specialist dr. ir. J.H. Engelhardt's dissertation also belongs in this series: 'Over het capillair fenomeen in relatie tot de hetrogeniteit van de grond' (About the capillary phenomena in relation to the heterogeneity of the ground) (1928).

After the Second World War these theoretical grounds are built up with model research, especially regarding the use of groundwater for drinking water.[392] Research using models is further developed by ir. D.N. Diets of the *Rijksinstituut voor Drinkwater-voorziening* (State bureau for drinking water) into the vertical-plate-model in 1958. He uses the Hele-Shaw principle (1897). This consists of two flat plates that are parallel to each other and separated by a small distance. At least one of the plates is transparent. These cells are used for studying many phenomena, including the behaviour of granular materials as they are being poured into the space between the plates. Poiseuille's Law of laminar flows (in principle the same as Darcy's Law) can be proved with this model. Diets made a model of the vertical section of the Netherlands over the Veluwe and the IJsselmeer to show the influence of season and rainfall on the discharge of groundwater. A very important result of this investigation is the creation of buffer lakes between the old and new land: Randmeren.[393]

In 1984 there is an article published in *De Ingenieur* about the economic, political planning of water storage. In the Netherlands in 1986 one million houses suffer from water nuisances of which 75 per cent are caused by groundwater. Most complaints occur with dwellings built from 1960 to 1980. The sites in this period are obviously not properly prepared for building. The emphasis in the article is placed on the fact that the quantity of housing and the choice of building sites are not properly considered. Sites less suited for building are chosen in combination with a minimum of filling with sand and no subsurface drainage for controlling the groundwater level to reduce costs.[394]

During the Manipulative period groundwater flows are finally brought to light. Previously everything was done on knowledge by experience but the developing science makes visible what the naked eye cannot see. The advent of the computer at the end of this Phase and the sensors that become possible improve the picture of groundwater flows even more.

VI Pile Foundations

In an article in *De Ingenieur* in 1931, ir. J.J. Springer reveals how little knowledge actually exists at that time about driving in foundation piles. Besides the effect that driving piles into the ground has on the soil, the load-bearing capacity of the piles can only be known by testing or (educated) guessing. Eytelwein's formula, known as the 'Dutch rule', is used for a long time when building in the province of South Holland.[395] For insight into the pressure in the soil Boussinesq is, for a long time, the only help. The common calculation is that the load-bearing capacity of a foundation pile is

[392] *De Ingenieur* (1958), B75
[393] *De Ingenieur* (1958), B780
[394] Bouwwereld (1986), 82; *De Ingenieur* 7/8 (1987), 28
[395] *De Ingenieur* 12 (1931), B 79

dependent on the skin friction and the resistance of the point. The skin friction is the sum of the horizontal soil pressure and the friction coefficient (the angle of internal friction plus the soil type).[396]

At first it is believed that negative skin friction will reduce the load-bearing capacity of the piles. More research is done into this phenomenon because a lot of houses are sinking, causing functional and economic damage. In Rotterdam this happens very often; 20 to 25 years after completion houses become worthless. Because they are on the verge of building a large city expansion, Blijdorp, the city of Rotterdam is very eager to look into this problem. They establish a committee on 2 September 1931: 'Commissie inzake Fundeeringen in Opgehoogden Grond te Rotterdam' (the commission looking into foundations in filled in grounds in Rotterdam). The committee considers different areas in Rotterdam, such as the area between the Nieuwe Binnenweg and Rochussenstraat, in Boschpolder and Tusschendijken. These areas are raised significantly around 1900 and houses are built there in 1905 (De Vliegerstraat, Snellinckstraat). The houses in the Rochussenstraat and De Vliegerstraat subside 40 to 50 cm. The conclusion is that the sinking is due to insufficient pile foundation, pile rot and negative skin friction.[397]

Another step in the developments in building on wet and weak soils is the introduction of the enforced concrete pile, the Franki pile, used for the Maastunnel in 1937.[398] The Belgian engineer Edgard Frankignoul (1882-1954) designs a system that makes it possible to cast the piles in the ground. The tube is topped with a concrete prop, when the pile is driven into solid load-bearing-capable soil the prop is separately stamped. The concrete goes through the tube that is simultaneously pulled up. The first tests with this method are done in 1933 in the Blijdorp polder in Rotterdam (see picture 5.7).

The reasons for replacing wooden with concrete piles at the beginning of the twentieth century are threefold. First is the rising price of wood, second the easy way of dimensioning the concrete pile to obtain a higher load-bearing capacity and reduce the amount of piles and third the independence of the concrete pile of the groundwater level. Wooden piles need to be below groundwater level (otherwise they will rot) and for concrete piles it does not matter. The concrete pile can be constructed and installed in four different ways. 1) The simple concrete pile driven in like the wooden pile. 2) The pile is built in the ground and the casing used for that is then removed. 3) The pile is built in the ground and the casting remains in the ground. 4) The composed pile, a combination of wood (under groundwater level) topped by a concrete construction.[399]

The Franki pile never left the building practice and gained a family member: the English Vibro pile. Instead of a concrete prop, the Vibro pile has an iron plate at the top and the concrete is not driven in, but vibrated into the ground. The vibration method is invented by Prof. Barkan (1939) and causes less noise inconvenience.[400]

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[396] *De Ingenieur* 2 (1931) B79; Commissie Inzake fundeering in opgehoogden grond, 1931
[397] *De Ingenieur* 7 (1932), B 181
[398] De Vet 1994, 8
[399] *De Ingenieur* 27 (1914), 534
[400] website http://www.geodelft.nl/nl/page3758.asp checked June 19th 2011

In the 1930s questions about the load-bearing capacity of pile foundations are still being asked. C. Franx writes an article in *De Ingenieur* about the different theories, of which the most common is that the load-bearing capacity is dependent on the solid layer on which the pile stands ('point bearing'). The other is that the pile gets its load-bearing capacity through negative skin friction. Franx suggests that both point bearing and negative skin friction contribute to the load-bearing capacity of the pile. It must be calculated to what extent.[401]

Many tests are still done on the load-bearing capacity of piles. A year later, in 1934, Franx writes an article about the Franki pile being tested in Rotterdam Blijdorp.[402] M. van Daalen adds to this the increasing of the negative skin friction as a method to enhance the estimation of the load-bearing capacity of enforced concrete piles. By altering the shape and surface of the pile, considering the soil type and the conditions of the site, this can easily be done.[403]

The only method to test the strength of the raised grounds or the load-bearing capacity of foundation piles is by actually testing with weight.[404] Due to the fact that it is only the second time that the method of spouting up sand is being implemented, there is no experience with what the piles will do in the layer of hydraulically filled sand. Two test piles are placed and studied for one year to find out. In the report of the Commissie inzake Fundeeringen in Opgehoogden Grond te Rotterdam (the commission looking into foundations in raised grounds in Rotterdam) calculations, the type of piles that are available and the costs involved are studied. It advises on the importance of good foundations for the well-kept appearance of the city, and emphasizes also the shortage of knowledge that still exists.[405]

In 1948 there is relatively little known about what really happens during the driving in process of foundations piles, for example about the stresses in the pile, or how to drive them in as efficiently as possible. Experience teaches that concrete piles are better driven in with a large heavy block that is lifted only a little, but heavier blocks also mean heavier machines.[406]

Besides the technology the organization of building with piles also needs to be developed. On 29 January 1946 the *Stichting Ratiobouw* (Rational Building Foundation), *Laboratorium voor Grondmeachnica* (Laboratory of soil mechanics) and the heads of the building inspection of the three largest cities, Amsterdam, The Hague and Rotterdam, agree on the establishment of a corporation to conduct research into the rationalization of soil technical preparations in building houses.[407]

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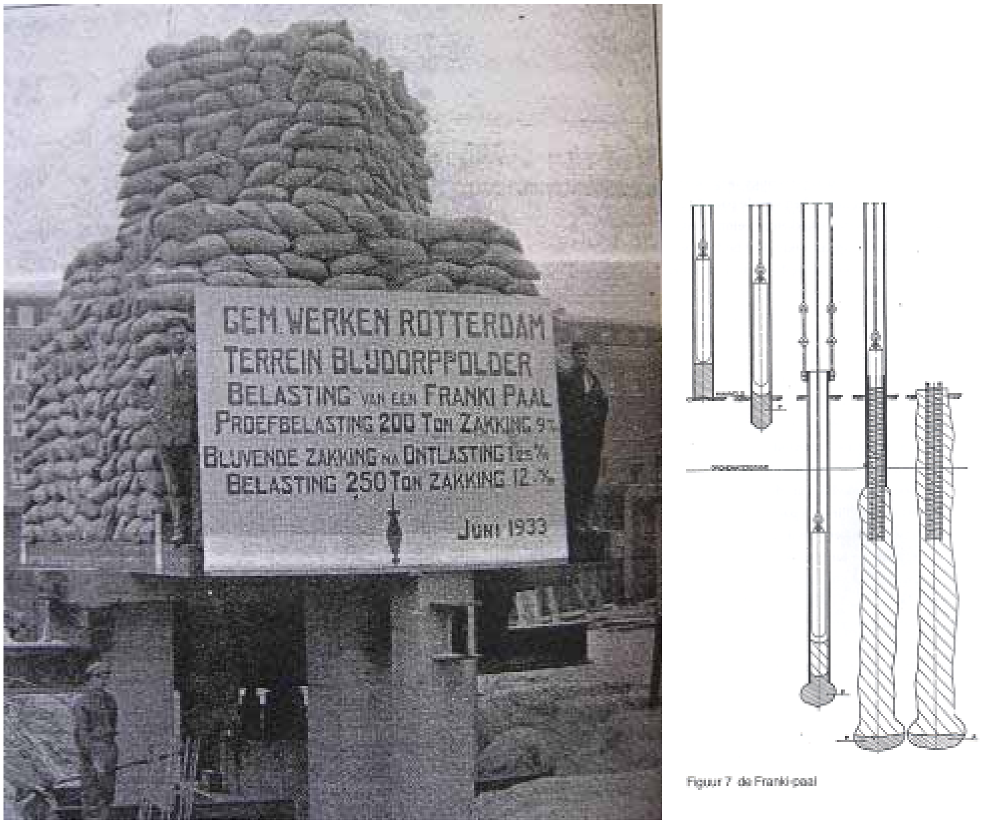
[401] *De Ingenieur* 13 (1933), B53
[402] *De Ingenieur* 16 (1934), B 45
[403] *De Ingenieur* 16 (1934), B 49
[404] *De Ingenieur* 2 (1931), B79
[405] Commissie inzake Fundeeringen in opgehoogden Grond te Rotterdam 1931, 12
[406] Duyster 1948, B79
[407] Havenwerken administratie A20/2 1946



Picture 5.7 Tests with the Franki piles in Blijdorp 1933
Source: *De Ingenieur* 1934

The question in the meeting is: What is the relationship between the *Laboratorium voor Grondmechanica*, as scientific advisor, the designer of the construction and the building police as controlling stakeholder in the designing and constructing of foundations? Since local knowledge and experience is very important in foundations – soil conditions are different everywhere – building inspectors play an important role in relation to the scientific advice of the *Laboratorium voor Grondmechanica*. The laboratory uses modern research methods and tests, while the know-how of the building inspectors is based on experience. Sometimes this results in conflicting advice and slows down the development of soil mechanics.[408]

The meeting also brings up the point of fast development after the war in building technology, leaving the building traditions and experience behind. Building regulations are based on these traditions and experiences. For example, the Amsterdam foundation formula that calculates the load-bearing capacity of wooden piles in the Amsterdam soil cannot be applied to concrete piles with a larger load-bearing capacity; the only way to find out is still by testing.[409]

The outcome of the meeting on 29 January 1946 is that the scientific knowledge of the laboratory should be used in combination with the local knowledge about soil conditions.[410]

[408] Havenwerken administratie A20/2 1946
[409] Havenwerken administratie A20/2 1946
[410] Havenwerken administratie A20/2 1946

Many different piles types and techniques to drive them in are developed, most to reduce the noise and vibration produced in the process. A new stroke hammer for the driving machine invented in 1980 produces a double driving force and a reduction of noise pollution. The Dijn-A-Cap has a piled disk spring that increases the power efficiently.[411] Also, vibrating instead of driving the piles in the ground provides advantages of less friction and less noise.[412] In Japan a method of screwing piles into the ground is developed that is less damaging and without noise. This method becomes a serious competitor for the driving in of piles in the Netherlands.[413]

In the 1970s the computer stimulates a fast development by, for example, the hydro block (RVS) a design of Hollandsche Bouw Maatschappij. Computers are also helping to predict the process of driving the piles into the ground.[414] Between 1976 and 1981 research is done into usable existing calculating models to assist in the prediction of the process of driving in piles for the foundation.[415]

For pile foundations the Manipulative era means quite some development. In the first instance the development of soil mechanics means a lot more knowledge about the different forces that influence the piles. Then the new engine power, after 50 years, also helps to make the driving more controllable. New piles of concrete are developed that are easier to dimension, do not rot and are cheaper. Different methods of driving in are developed and calculations can be made more precisely; at the end of the era the computer especially contributes to this. Yet, the load-bearing capacity of piles is not fully predictable.

VII Drainage Systems

The first drainage subsurface systems are applied to raise larger areas like railway emplacements. In 1886 *De Ingenieur* writes about the Leeuwarden station, the raised area has drain problems. After rainstorms the water does not drain fast enough and leaves pools of water on the emplacement. The compressed ground is impermeable and for sufficient draining of the area, grooves with pebbles are built: 20 cm wide and 90 cm deep and descending sideways towards the side ditches. The grooves provide a perfect discharge of rainwater and are better than the use of drain tubes because those can break under the pressure of the heavy trains.[416]

In a later edition E.J. de Savorin Lohman writes that they have positive experiences with drain tubes with the station emplacement in Groningen. They have been functioning perfectly for the past seven years and also with seven other stations along the rail line to Delfzijl. The use of subsurface drain tubes is 21 times cheaper than the construction of grooves with pebbles. The tubes should be put in subsided soil, around the tube there should be clay, and not sand or pebbles or then the tube will get clogged. Under an emplacement the drains should be put some centimetres below the

[411] *De Ingenieur* 3 (1980), 18
[412] *De Ingenieur* 27 (1963), B147
[413] De Vet 1994, 27
[414] *De Ingenieur* 7 (1980), 13
[415] *De Ingenieur* 16 (1981), 16
[416] Beversen 1886, 315-316

ballast layer so that they cannot break, and are easy to dig up and clean. He advises the French publication by J.M.J. Leclerc, *Traité de drainage Brussel* (1853, second edition 1857).[417]

At the end of the nineteenth century the world of engineers is divided about subsurface drains. Besides situating the drain in relation to the flow of the groundwater, which is still a mystery, the design of the drains (a closed tube or half a tube with the open side down) is also discussed. Penninck advises the use of half tubes with the openings at the bottom to ensure that the flow of water and sand does not clog the drain.[418]

Next to the subsurface drains the sewer is a big topic of discussion, which had already started in the former Phase. At the start of the journal in 1886 G. van Overbeek de Meijer argues in *De Ingenieur* that the sewer should be a separate system, one pipe for the sewer and discharge of rainwater the other for groundwater that should be discharged separately by means of small drain pipes.[419] At that time there is little information about the amount of rain that falls from the sky per hour because meteorological institutions measure it per day only. The Author is aware of the fact that various factors determine the amount of water that is discharged – the atmosphere and the temperature, the moisture of the soil, the elevation of the terrain, if it is descending, the proportion of closed and preamble surface (roofs, streets, squares, gardens) and the size of the rain storm area: the larger the area the larger the discharge. According to observations in London, 50 per cent of the storm water ends in the gutter, in dense areas 94 per cent. The discharge takes three to four times longer than the time of the storm, so one third goes into the sewer system.[420]

In Dresden (Germany) Mank[421] and Baumeister work on the same issue. Baumeister presents the following formula determined by the constant that came from the measurements of how much time a drop of water needs to move over the line (l) in metres from the storm area to the sewer, with a slope (α) in percentage (g is gravity):

$$\sqrt{\frac{2l}{g \sin \alpha}}$$

The time that the drop needs is in comparison to another area of the same size equal to √l. When the area is a square l is √ F, F= the size of the area in hectares. A is the maximum amount of litres of water discharged per second/per hectare and R is the average rain fall in litres per second/per hectare. Baumeister claims:

$$\frac{A}{R} = \frac{\alpha}{\sqrt[4]{F}}$$

[417] *De Ingenieur* (1886), 373
[418] Penninck 1896, 579
[419] Van Overbeek de Meijer 1885; *De Ingenieur* (1886), 26-27
[420] *De Ingenieur* 15 (1887), 113
[421] Deutsche Bauzeitung 1884, 170

Plaats.	Datum.	Duur van den regen.	R (in Liter per sec. en per HA.)	A (in Liter per sec. en per HA.)	F in HA.	z berekend uit $z = \frac{A}{R} \sqrt[6]{F}$
Munchen (verzamelkanaal)	12 Augt. 1873	¼ uur	280	24	196	0.3
Elboeuf (Beek)	5 Juni 1873	2 »	104	15	1150	0.8
Budapest (Teufelsgraben)	26 Juni 1875	1 »	183	45	2000	1.7
Londen (Savoy street Canal)	20 Juni 1857	1¼ »	55.5	30.7	61.5	1.5
Stuttgart (Nerenbach)	23 Juni 1875	1½ »	54	14.5	2222	1.9
Kussnach (Dorfbach)	3 Juni 1878	½ »	143	38.8	1200	1.6
Zurich (Riesebach)	»	»	»	27.3	1400	1.2
» (Wolfbach)	»	»	»	70	100	1.6
» (Hinterbach)	»	»	»	85	34	1.4
» (Häldelisbach)	»	»	»	55	65	1.1

Picture 5.8 Baumeister’s calculation table
Source: *De Ingenieur* 1887

Baumeister compares the data above in picture 5.8 The first two areas are flat terrain, the last group has a value of α between 1.1 and 1.9, and the average is 1.5. Atmosphere is taken as the same in all groups and the details about the buildings are missing. The calculation shows that in a dense area the sewer must discharge double the amount rainwater in comparison to a wide-spread city. The conclusion is that on flat terrain in the low density city α has 0.5 and the dense city α is 1; and on sloping terrain the spread out city α is 1 and the dense city α is 2.[422]

Lienus and De Bruijn Kops argue that a separate sewer for rainstorm water is not necessary because the water that will remain on the street before discharging will never be more than half of a shoe sole, about 2 mm. With a severe rainstorm the discharge is fast enough for people to wait a few minutes before using the street and thus keep their feet dry.[423]

Important calculations in considering the flow of rainwater in the city are developed around 1910. The calculation of the delay of the water flow (Q=OxI) is especially important for the amount of water that can be expected at a certain place and time.[424]

Besides the development of continuous subsurface drainage for the city, temporary drainage is also designed. In *De Ingenieur* of 1903 attention is paid to the method of pumping wells for the first time. This is done to have a dry excavated site when the foundation is driven in. The first time this is done is with the theatre in Oldenburg in 1870 by the use of four iron tubes with holes, driven into the ground vertically, attached to a pump. This method is also used to build the drinking water system in Leipzig.[425]

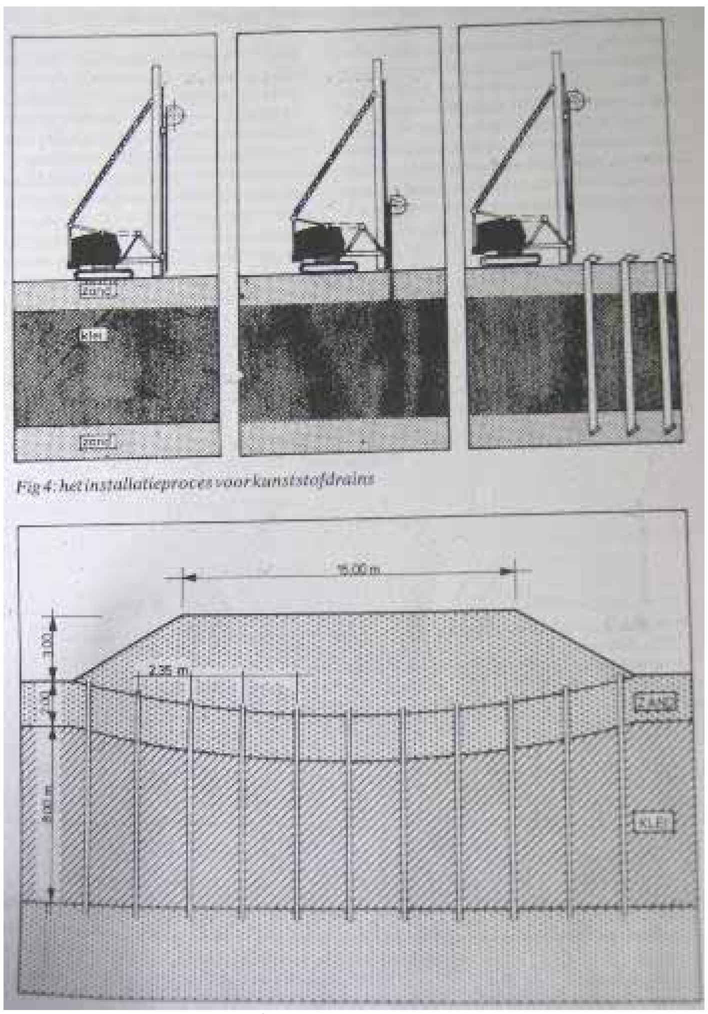
The consolidation process of sand layers can take a lot of time because the water has to flow out of the clay layers, which are hardly permeable. Different methods are developed to hasten this drainage process; O.J. Porter (USA) has the idea in 1930 of the sand pile as a vertical drainage system. The use of vertical drainage shortens the distance the water has to travel to an outlet. In the 1950s the Rotterdam Public Works Department introduces the vertical sand drain in the Netherlands. Together with Nederhorst N.V. they develop it further with a flushed hole. The improvement over drilling a hole is that there will be no pinched soil that can block the horizontal flow of the

[422] Deutsche Bauzeitung 1884, 177
[423] Lienus and De Bruijn Kops 1885
[424] De Meyier 1912, 517
[425] Van der Steen van Ommeren 1903, 289

water to the drain.[426]

In Sweden in 1935 Kjellman suggests the 4 x 100 mm cardboard drain with vertical open corridors for constructing airport landing strips. It is specifically meant for faster consolidation of clay soil. This type of drain evolves in many plastic successors, of which the Colbolddrain and the Tubedrain have the largest drain capacities.[427]

Until the 1970s the groundwater level is controlled with surface water systems. Particularly under influence of the IJsselmeerpolder Development Authority (Rijksdienst van de IJsselmeerpolder) other solutions for urban drainage to keep the groundwater level low are investigated. Raised building sites need to be drained and because of the vulnerability of drain systems during the building Phase specific preventative measures need to be taken. To put the drain system deeper (up to 3 m) can be a solution, together with plastic drains that are easy to work with. Also the cross drainage, two drain systems that overlap crosswise, makes drainage optimal.[428]



Picture 5.9 Installation of plastic drains in a cunet.
Source: *De Ingenieur* 1960

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[426] See: Gemeentewerken Rotterdam 1984
[427] De Vet 1994, 36-37
[428] Segeren and Hengeveld 1984, 30

In order to mechanize drain installation methods, plastic (PVC) instead of conventional tile drains is applied successfully. Plastic pipes differing in diameter and area of perforation are investigated in a sand tank for drainage performance in comparison with tile drains.[429] In 1971 the first plastic drain, a corrugated, perforated PVC pipe, is introduced by Bato-Jansen BV on their wharf in Alphen aan den Rijn. A year later the Swedes also make a plastic drain, the Gedrian; then a turbulent development in drains follows. By 1978 5,000,000 m of plastic drains are used in the Netherlands.[430]

Due to the fact that especially after the Second World War an increasing number of drains are necessary to make building on weak and soft soils possible, the development of knowledge flourished during the Manipulative era. The application of a layer of sand as the most effective method of building-site preparation made drainage of the agricultural sector develop into a necessary condition for urbanism.

From Seven Fields of Knowledge to Three Urban Typologies

The attitude of manipulation is not restricted to water management but becomes the leading paradigm applied to all different sectors including the social structures. The *maakbaarheid* paradigm becomes very strong after the Second World War in the *Wederopbouw* (reconstruction) of battered Netherlands. In reaction to the period of depression (before the war) and the experience of devastation of the war, it is embraced with euphoria: the world will be a better place, society will be made into a trustworthy institute and cities will also make people happy and well functioning, resulting in the neighbourhood city urban model.

This new technology brings about a new organization of city development and initiates a cultural change that disconnects nature from culture and urban design from the physical geographical conditions of the site. The accelerating powers during the Manipulative Phase bring to all fields of knowledge an incredible development, even for the few that start from zero. Of course the development of engine power is the most influential, both in the technological and the urban sectors. Industrialization changes social, economic and spatial patterns and scale in almost every way possible. The technological developments support general water management into an even better-organized specialized sector with an up-scaling of the control that is exercised over the water system, with the use of very small-scaled technology. The natural system, the water wolf, is brought under strict control.

Soil mechanics, soil improvement, hydrogeology and drain systems are the fields that come from zero to a situation where especially in combination they provide solutions to make all natural systems controllable. Technically everything can be made possible, and cities can be built anywhere, and computers can visualize and calculate everything.

Urbanism ignores physical geography due to the fact the combination of the science of water management, soil mechanics, soil improvement, hydrogeology, drain systems and pile foundations can place any city

[429] De Jager 1960, B167
[430] *De Ingenieur* 13 (1979), 239

anywhere. The hydraulically filling is economical and for the production process very attractive. Modernization is the new state of mind, new technology, new knowledge development, the new national and urban organization are accelerating on the foundations of the principle of *maakbaarheid*.

The developments in the seven fields of knowledge are the basis of the developments in methods of building-site preparation. In the same year (1984) that Segeren and Hengeveld publish their bible, the Department of Public Works in Rotterdam, leader in the development of knowledge about building-site preparation, wrote the report: ‘Methoden van bouw- en woonrijp maken in de gemeente Rotterdam’ (Methods of building-site preparation in Rotterdam). It gives a nice overview of the available methods of building-site preparation at that time: at the end of the Manipulative Phase. Due to the development of new techniques they felt an urgency to evaluate the methods that were used before, to steer the discussions going on between developers (the municipality), urban designers and civil engineers of the municipality. Their research into six traditional and three alternative methods led to the conclusion that taking into account the usual starting point of land use, dwelling differentiation, investments, maintenance costs, and phasing, the traditional method of applying a layer of sand with vertical drainage is preferred.

Traditional methods:

- I. Sand in road strips (cunet) transported by truck;
- II. Sand in road strips (cunet) transported by rail with vertical drainage;
- III. Hydraulic filling (layer of sand without vertical drainage);
- IV. Hydraulic filling with vertical drainage;
- V. Filling with sand transported by truck and with vertical drainage;
- VI. Filling with sand transported by truck and then covered by a layer of sand by hydraulically filling and with vertical drainage.

Alternative methods:

- VII. Polystyrene and other light materials in road strips;
- VIII. Living platform method where buildings, roads, sewer and cables are built on foundation piles;
- IX. Lowering of the groundwater table in combination with the partial method II.

This overview of methods is helpful for the following three chapters where the methods and the urban form they result in are described in more detail. In the former Phases these urban typologies were part of the chapter but the acceleration between 1890 and 1990 resulted in three urban typologies: chapter 5a ‘Accelerating Machine Power’ (pre-war), 5b ‘Accelerating Manpower’ (post-war) and 5c ‘Accelerating Flower Power’ (1970s). The pre-war type still contains ‘connectors’ to the original hydrological situation, like open water systems, even though areas are spouted up with a layer of sand. This is due to lack of knowledge about the exact effects of soil mechanics, groundwater flows and foundation piles; and because drains are not used. The post-war type is characterized by total disconnection from the landscape and the hydrological system, made possible by excellent technology. The last urban typology of 'Accelerating Flower Power' is the reconnection with the landscape and ecology. The landscape architect enters the arena of spatial planning and a new method of building-site preparation, partial filling, gives way to nature and water in urban expansions.

In each chapter the general urban features of the urban typology are studied followed by the methods of building-site preparation that are used at the time. Each chapter than contains cases from Rotterdam to explain the construction of these types in detail. Connections are made to other examples and also to plans that have never been executed.

Chapter 5a: Accelerating Machine Power (1890-1945)

Booming industrialization and urbanization

This subchapter goes into the first urban typology in the Manipulative Phase from 1890 until the Second World War (1940-1945). Urban expansions in the pre-war years are concerned principally with polder towns and characterized by an interaction between the scale levels of the liveable neighbourhood and the region. As industrialization advances, industry and workers' housing are concentrated in cities. This industrialization is called the Third Industrial Revolution (1908-1947) and is mainly instigated by developments in petrochemicals, the internal combustion engine and electrification.

As the former chapter introduces, the fields of technology develop from knowledge by experience to scientific knowledge in specific fields; bringing about specialization and organization of the different disciplines. The architects are independent from the engineers and form a separate discipline in education, in societal aspects, in theory, etcetera. The urban designer is a new and upcoming figure and discussions are held as to what extent this is an architect concerned with connecting technology with aesthetics, or a social engineer, concerned with a range of urban aspects and relying on different fields of knowledge.[431]

Picture 5a.1 Just prior to the Manipulative Phase, Rotterdam in 1880. The river, the city's namesake, is replaced by an iron highway.
Source: Municipal Archive Rotterdam

[431] For this era again the work of Auke van der Woud (2010) is not to be missed for a good understanding of the transition that really takes place.

The Housing Act that makes expansion plans mandatory for larger municipalities gives the urban designer a designated project; it is about large-scale infrastructure, housing and introducing green structures, it is about hygiene, light and air in the city; organizing the building for the market, separating private from public, it becomes a challange that needs survey to be able to place all the aspects in order. Due to the Housing Act, which is mainly set up to prevent bad housing conditions, housing is the main driver in this era. The functional separation of zones for better hygiene is one way of solving these issues, an aspect already used in the former Phase. The garden city as a contra mal for the industrial city is one of the ideals.

This first urban typology is comparable to Brown's sewered city, one of the six distinct, cumulative transition states in the development of urban water management in Australia.[432] The sewered city is concerned with public health and separate sewer schemes are set up. This is comparable to the Dutch societal concerns about public health, criticism from doctors and engineers involved with hygiene, rapid urbanization, changes in legislation and normative and behavioural changes at the beginning of the twentieth century.

Picture 5a.2 Impression of how (wet) the landscape is before the city expands over it.
Source: Municipal Archive Rotterdam

When surface water is no longer important as a transport route and as a sewer, the urban structure changed. Till the end of the nineteenth century coherent urban tissue is built up by the structures surface water (canal, *singel*), road and house, as in the *Grachtengordel*, now the roads and buildings form the main structure while water and green together become a

[432] Brown et al. 2008

separate secondary structure; surface water gaining the new function of public space: fitting the garden city.

The case in Rotterdam that is chosen to represent this urban typology is Blijdorp. It is the second time that hydraulic filling method is used as a method of building-site preparation and the series of urban plans made for this area show how scale enlargement, industrial building and infrastructure start to take over the shaping of the city.

Garden Cities

The use of steam-driven pumping stations for the city expansion of Rotterdam is one of the first examples of a technological approach to urban water, which will become common property a hundred years later. The most important input for this development is technological progress in combination with an explosive growth of urbanization. Hygiene problems, caused by the city's water are slowly but surely of influence to the spatial effect of water management, due in part to the progressing development of the steam engine and later of the combustion engine.

Another major influence is the Housing Act 1901 and the development of hydraulic filling that allows for very effective and efficient building-site preparation on a larger scale.

The first make municipalities think ahead on a larger scale and to future demands for the different urban functions. Also the practice of urbanizing the polder pattern by private developers becomes very difficult to organize. At the same time the Housing Act makes it possible to fund housing corporations to provide good housing on a larger scale. All these aspects result in the decision by municipalities to buy the land and develop the expansions themselves. Rotterdam Blijdorp is an example of this development where use is also made of the new development of hydraulic filling.

The scale enlargement of city development is due to the demands of the Housing Act of 1901, the new industrial building methods and the hydraulic filling for building-site preparation. The wholesale filling of expansion areas becomes less expensive and the Housing Corporations develop large-scale blocks on the new city layout, which loses its connection to the original polder pattern. Methods of estimating and new drainage techniques also have a major impact on the structuring role of water: it also loses its final meaning of drainage and storage.[433]

The Garden City movement of Raymond Unwin and Ebenezer Howard around the turn of the century and Tony Garnier's design for a *Cité Industrielle* (1904) are examples of a quest for new concepts for the relationship between city and landscape. These ideas divide the thinking on design into elaboration, construction, planting and building typology on the lowest scale level. Howard is concerned with the human scale and the enjoyment of air and space. He develops a garden city concept in which a large city is surrounded at some distance by a ring of satellite towns (with a

[433] Van Eijk 2002, 355-356

maximum of 32,000 residents) having rural qualities and a higher level of welfare and happiness. Tony Garnier counters with the idea of the *Cité industrielle* (1904, published in 1917), a linear city, carefully situated in the landscape, and extendable.[434]

These concepts also take root in the Netherlands, nourished by the uncontrolled spread of the cities and the rapidly deteriorating urban hygiene and environment. The large-scale building that starts after breaking open the cities is scarcely supervised by the 'freelance' builders involved. The motive behind the sprawl is the builders' self-interest; there is no place for a communal quality of the city. The requirement for space for public greenery is reinforced around 1900 through the influence of Boards of Healt, which are founded to promote the hygienic interests of the city. Furthermore, the 1901 Housing Act is the first legal instrument for shaping the city in a controlled way, and facilitates the planning of greenery in the city.

Alongside traffic, building and water, a new element therefore appears in the urban network: public space. Simultaneously, the networks of building, traffic, and the combination of water and greenery are distanced from each other. These networks coincide in the traditional city. For instance, Amsterdam's *Grachtengordel* has one main structure comprising all the elements. It appears that only together can water and greenery guarantee their claim to urban space at the start of the twentieth century. Water is part of the green structure, and the greenery acquires a right to exist as the exponent of water in its function of public space. The composite structure of greenery and water originally retains some importance, and together with the traffic network they form the backbone of urban design.

The unshackling of the water structure (with greenery) and the traffic structure progresses in the twentieth century. The structure of water and greenery in Plan South (Amsterdam) and in Blijdorp (Rotterdam) follows the traffic structure like a detached shadow. The building in both municipal districts accentuates the main structure in a traditional way. The style of building in continuous rows is applied sparingly, as in De Eendracht in Blijdorp (J.H. van den Broek).[435]

Except for the expansions in Amsterdam and Rotterdam, most urban development plans in the 1920s remain on paper because of the economic crisis. The urban development issue shifts to a regional scale, as illustrated by Albert Plesman's proposal in 1938 to give the ring of cities in the west of the Netherlands the collective name 'Randstad'. Amendments to the Housing Act in 1931 give regional planning an official status. Growing mobility puts pressure on the space in the city and surrounding areas. Sustained industrialization demands a separation of functions on a regional level. The Director of Local Works, W.G. Witteveen, develops a city plan for Rotterdam in 1926 oriented to large-scale infrastructure, including ring roads. Although this plan is not executed, its starting points are visible in the sub-plans that are realized, such as the one for Blijdorp of 1931.[436]

Thinking about the city is moved forward by various groups of architects, such as De Opbouw (1920), De 8 (1927) and the CIAM (1928).

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[434] See for the Garden City movement Isaacson 1988 and Howard 1902.
[435] Stroink 1981, 109-111
[436] Witteveen 1929, 169-179

Several CIAM conferences are dedicated to the 'functional city', in which the functions are spatially separated, with the objective of introducing light, air and space into the city. The style of building in continuous rows is introduced in order to align the buildings with the sun, for maximum light incidence. One product of these ideas is presented by CIAM member Cornelis van Eesteren in 1934 in the AUP. Together with Th.K. van Lohuizen he introduces the survey and the science of urban design. According to Van Eesteren the art of urban design enables the combination of elements like water, greenery and height differences in a spatial plan. The investigation plus the art of urban design together determine the shape and expression of urban design.[437] The added value of the survey is explored extensively in the AUP, which is evident in the size and content of the clarification of the plan and the separate report that is made 'Rapport der Commissie, ingesteld door Burgemeester en Wethouders van Amsterdam, ter bestudeering van het vraagstuk van het bouwen al dan niet op opgehoogden grond' (Report of the commission, appointed by the burgomaster and aldermen of Amsterdam, to study the question about building on heightened or non-heightened grounds).[438]

Picture 5a.3 Report of the commission, appointed by the burgomaster (mayor) and aldermen of Amsterdam, to study the issue of building on heightened or non- heightened grounds.
Source: Author

Van Eesteren pays a lot of attention to the water issue and building-site preparation methods in the AUP. Each subject has a whole chapter devoted to it: chapter 10 is about the canal system and chapter 14 about the filling of the area. The fact that he has a separate report prepared about the availability of sand from natural mining fields in the region shows the significance of the fillingissue for his plan. Van Eesteren explains why and at

[437] Vanstiphout 2005, 163

[438] Commissie bouwen op opgehoogden grond 1931

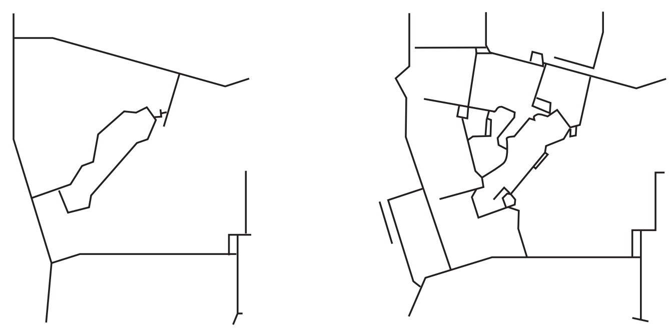
the same time makes the relation between the water level and the urban design very specific:

> The arrangement of the system of waterways, the water storage area, the system of sluices and pumping, are all controlled through the land level achieved by filling . A city built as an (outlet waterway) *boezem* town has to be developed in an entirely different way than a polder town.[439]

Because:

> . . . an urban expansion executed in this way [as a polder town, FH] will have to be laid out to suit the pumping, one consequence of which will be a need to reserve a considerable surface area of the city for canals and watercourses to arrange for sufficient water storage.[440]

In a *boezem* town the water can be directly discharged through the *boezem* and extra space for storage is not necessary. Van Eesteren is the first to explicitly connect the influence of water management to the urban design of the city by recognizing this fact.



Picture 5a.4 Difference between the water system in the *boezem* town (left) and the polder town (right)
Source: Author

Although water structures still play a functional and aesthetic role in the pre-war years (for instance in Plan South and in Blijdorp) the same is not true of existing water structures. Filling water structures to hide bad smells, to solve traffic problems and for other spatial reasons, continues. A great example, which damaged the dam city typology of Amsterdam is the Rokin, which is filled in (1933) leaving the dam without water [441]

Plan South Amsterdam

Architect Hendrik Petrus Berlage (1856-1934) is asked by the municipality of Amsterdam in 1913 to design a plan for the new city area between the rivers

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[439] Van Eesteren 1934, 159
[440] Van Eesteren 1934, 25.
[441] The study by De Vries 1996 is showing good insight in the filling and reconstructing historic waters

Amstel and Schinkel. The area is annexed from the neighbouring municipality Nieuwe Amstel to solve the housing problems in the existing city. In 1904 Berlage presents a plan with small-scale streets and buildings that connects perfectly to the existing city. The plan turns out to be very expensive and inefficient in the realization of enough housing and Berlage is asked to make a new plan. In 1914 he presents the geometrical and monumental plan with straight streets and large blocks that is accepted by the Council in 1917. Berlage wants the geometrical design to express the idea of a society without class differences, order and beauty should lift the labourers from their daily misery.[442]

Berlage, as a socialist architect, is inspired by Sitte and A.E. Brinckman (1881-1938), writer of *Platz und Monument* (1908) and after a study trip to the USA also by the orthogonal urban pattern and the City Beautiful Movement. Plan South refers directly to Frederick Law Olmstead's Boston Park System in its profiles and use of axes.[443] Also Otto Wagner's plan for Vienna and Haussmann in Paris serve as examples in aristocratic classicist urban design. Walt Curt Beherendt has an example in his practical aesthetics described in *Die Einheitliche Blockfront als Raumelement im Stadsbau* (1911). The use of the city block as an aesthetic means to make an urban plan is promoted in this publication, with examples like Rue Rivoli in Paris and Regent Street in London.[444]

The water structure is necessary for the drainage of the area and forms a transport route between the Amstel and the Kostverlorenvaart. A park is situated along the water to provide a walk along the water.[445] The water structure in the first plan of 1914 is, like the plan itself, much more in landscape style than the second plan where the water has a geometrical form and also has significantly less square metres. However, in surface and structure they are similar, showing the logic of the water route and drainage capacity.

Plan South 1917

The whole area is purchased by the municipality and raised to 0.70 m +MSL, the water level is 0.40 m -MSL, being the level of the *boezem*. These levels are made compulsory in the first building ordinance of Amsterdam in 1902[446] to prevent the problems experienced in the nineteenth century when expanding the city.[447] The sand is taken from the sluices in IJmuiden between 1915 and 1930. After that runs out, the sand is extracted from lakes in Nederhorst den Berg, Kortenhoef and Vreeland. The sand is vacuumed into boats and transported to the site by train.[448]

In 1927 a commission is formed to study the means of building-site preparation in Amsterdam because the costs of filling to *boezem* level are very high. The inventory led to the conclusion that the whole city is largely

[442] Architectura 1915, 68-71 and 76-78 explanation of the plan by Berlage.
[443] The Back Bay Fens was a noxious tidal swamp and creek left over from the times when the whole Back Bay was a shallow body of salt water. Olmsted devised a plan the Boston Park System that solved the drainage problem. For more information Zaitzevsky 1982.
[444] Hoogenberk 1980, 100-101
[445] De Jong 1985, 217
[446] For this project these are not studied, it would be interesting though to study all the Amsterdam building ordinances on the theme of water levels.
[447] Segeren and Hengeveld 1984, 27
[448] Janse 1993, 33

built on *boezem* level, thus above 0.40 m -MSL. The annexed towns are usually built one or more metres below 0.70 m +MSL; also the city parks Vondelpark, Sarphatipark and Oosterpark are built at polder level because filling is too costly. Watergraafsmeer is also not raised and is a typical polder city at 5.50 m -MSL.[449]

Picture 5a.5 Plan South 1904
Source: MaartenJan Hoekstra

Picture 5a.6 Plan South 1917
Source: MaartenJan Hoekstra

It is interesting, in concluding this paragraph, to note that the urban model that 'cures' the pains of the industrial city, the garden city, is going to be realized in an industrial landscape: the layer of spouted up sand. The reasons for having surface water in the pre-industrial city alter completely with the industrial revolution and the only function that remains is as a part of public space. The making of the city does not depend largely on the conditions but visa versa; the conditions for the city are created in any circumstances.

[449] Commissie bouwen op opgehoogden grond 1931

Building-Site Preparation before the Second World War

In 1919 the report 'Vraagstuk van de grondwaterstand te Rotterdam' (The problem of the groundwater level in Rotterdam) by the Department of Public Works is published. The summary and conclusion give a nice overview of the available technology and how these are applied at the beginning of the twentieth century. The first time sand is spouted up in Rotterdam is in Hoboken and the second in Blijdorp. This case shows the fact that the ability to spout up sand exists, but the effects of soil mechanics, groundwater flows and foundation piles are still largely unknown. Drains are not used in this case and the subsidence in this area is so severe that sand has to be added several times to achieve the desired height.

The summary and conclusions of the report by Burgdorffer (Director of Public Works):[450]

1) City development with closed building rows and paved streets gives reason for groundwater level lowering.
2) This lowering is inconvenient only for the wooden foundation piles that need to be under groundwater level.
3) Between 1891 and 1892 Rotterdam built a deep sewer system and complaints about declining groundwater levels started in 1904.
4) The inner polder city of Rotterdam had local (parts where the sewer is very deep) groundwater level lowering that caused dry foundations and façades to collapse.
5) Deep lying sewer pipes cause the groundwater level to go down.
6) The sewer system [in Rotterdam] is in perfect shape.
7) To avoid the problems mentioned above, the advice is to spout up sand on building sites; the subsidence will be more even and sewers more stable.
8) Using the 'cunet' method, sand strips under streets, is advised after hydraulic filling .
9) Lots that suffer from subsidence should apply foundation lowering to prevent façades from collapsing.
10) In cases of pile rot in an early stage the committee advised the building of a groundwater barrier to prevent further groundwater level lowering on that plot.
11) Separating streets lots from building lots with a groundwater barrier can be done with new expansion without high costs and prevents a lot of trouble.
12) Negative advice for foundation of sewer system.
13) To keep the sewer water tight (in weak soil as in Rotterdam) is impossible.
14) Connecting the sewer to the foundation of houses can only be applied when the houses are developed by the municipality.
15) Keeping the streets wet by irrigation is not feasible.
16) When point 11 is not applied the groundwater level needs to be accurately monitored, the only way to be sure that piles are under

[450] Burgdorffer 1919

groundwater level is by situating them under the lowest level of the sewer system, necessary data need to be published and taken into account with the building inspectors.

17) Constructing a rot-free foundation is advised; especially reinforced concrete could be useful.

The proposals consist of three groups: A) regulations for the existing city, B) regulations for new expansions and C) some more general remarks.

A) Regulations for preventions in the existing city:
1. The building inspection needs to monitor the state of foundations. For prevention the municipality should act forcefully in case of damage and danger.
2. When foundations are already damaged but still have enough load-bearing capacity, or in a situation where the foundation could be harmed, the municipality should regulate the construction of a groundwater barrier and the lowering of the foundation.
3. In cases where the foundations are dangerously harmed, they should be lowered immediately.

B) Regulations for prevention in new expansions:
1. The new expansion should be integrally raised, preferably by hydraulic filling, when there are no financial objections. The site should be heightened more than necessary and years before building activities start.
2. If case number 1 is not possible the sand strips under streets should be over-dimensioned as well.
3. In the case of the municipality building the housing blocks, and numbers 1 and 2 not being possible, a test should be done with attaching the sewers to the foundation of the houses.
4. Foundation piles should be constructed in reinforced concrete as much as possible.
5. Wooden piles can only be placed using a groundwater barrier and significantly lower than usual.
6. Article 41 of the building regulations needs to be adjusted on the point of the highest foundation level for wooden piles when no groundwater barrier is used.

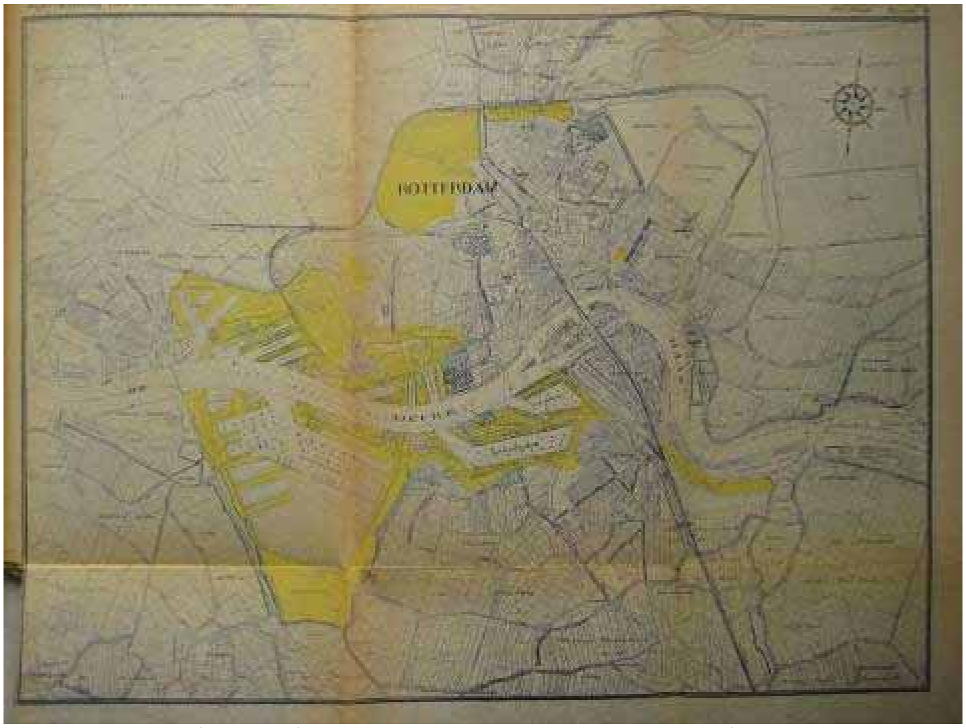
C) General remarks:
The municipality has to inform architects, contractors and builders by:

1. Ordering data about level of sewers, groundwater levels, level of existing foundations and foundation lowering that have been done.
2. Data concerning foundation constructions and applications.

These data need to be kept accurate.

Picture 5a.7 Map of Rotterdam in 1900. North of the city has grown far beyond the *singel* of the *Waterproject*. West of the *Waterproject* a large harbour is drawn but never built. The city is using the polder pattern as master plan.
Source: Municipal Archive Rotterdam

Rotterdam and Amsterdam both had their Departments of Public Works write reports about questions in raised areas in 1931: the ‘Rapport der Commissie inzake Fundeeringen in opgehoogden Grond te Rotterdam’ (Report of the commission looking into foundations in raised grounds in Rotterdam) and ‘Rapport der Commissie, ingesteld door Burgemeester en Wethouders van Amsterdam, ter bestudeering van het vraagstuk van het bouwen al dan niet op opgehoogden grond’ (Report of the commission, appointed by the burgomaster and aldermen of Amsterdam, to study the question about building on raised or not-raised grounds).

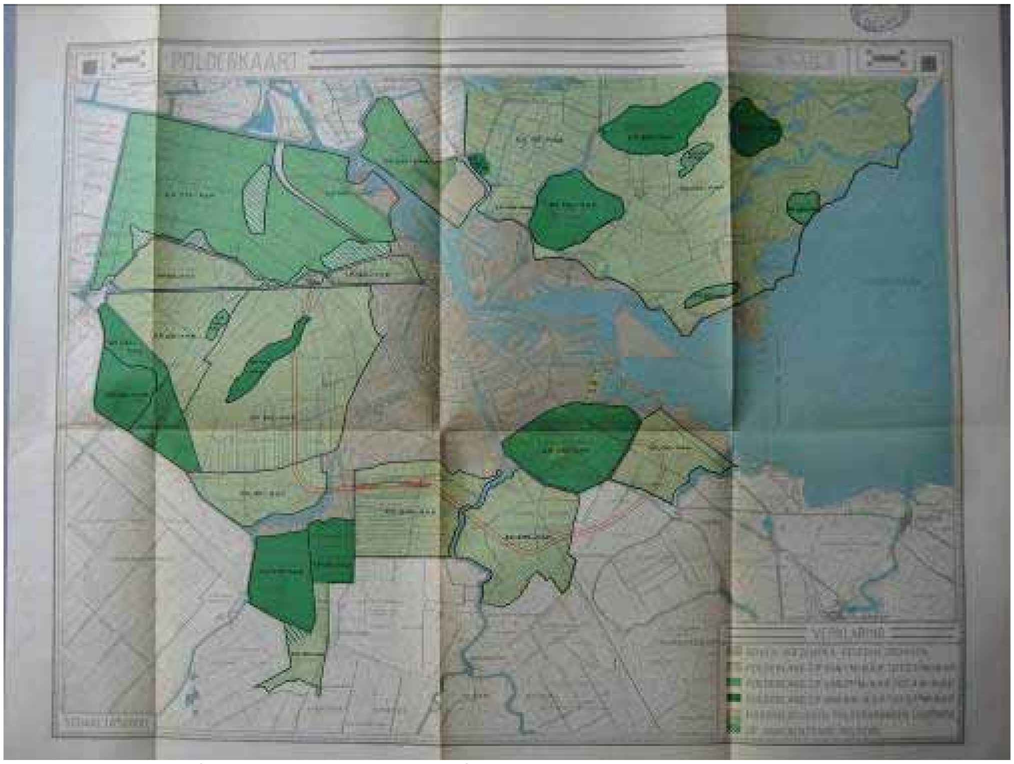


Picture 5a.8 Map of already filled in grounds in Rotterdam: Hoboken (first project hydraulically filled in), Bospolder Tussendijken and large harbour areas.
Source: Commissie inzake Fundeeringen in opgehoogden Grond te Rotterdam 1931

The Rotterdam report 'only' studies pile foundation because of the new developments in Blijdorp. A map of areas that have already been raised is included showing Hoboken (also spouted), Bospolder Tussendijken and some areas in the harbour. A study of the literature is included and it is interesting that the most important source for this is *De Ingenieur*, apparently the place for these issues.[451] The report also goes into the importance of good foundations for the well-kept appearance of the city, and the shortage of knowledge that still exists and the case Rochussenstraat.[452] It studies calculations, the type of piles that are available and the costs involved.

The Amsterdam report concerning the question about building on grounds that are raised and not raised that Cornelis van Eesteren used to make the General Expansion plan of Amsterdam (UAP) is very interesting. In chapter one this plan is used as an example of how the physical geographical circumstances and the technical attitude towards them are important for the design of the city. This report clearly offers the ammunition for the AUP.

451 Commissie inzake Fundeeringen in opgehoogden Grond te Rotterdam 1931, 7-10
452 Commissie inzake Fundeeringen in opgehoogden Grond te Rotterdam 1931, 12



Picture 5a.9 Map of the situation and level of the polders around Amsterdam
Source: Commissie bouwen op opgehoogden grond 1931

In the report the exact difference between a *boezem* city and a polder city is extensively explained and analysed. A *boezem* city has the water on *boezem* level (and the street level 1 m above that) which means a direct discharge into the *boezem*, the outlet waterway to the river or larger water. The polder city has the water on polder level (and the street level 1 m above that) which means no free discharge but the necessity for pumps to move the water up to the *boezem*.[453] Amsterdam has always been a *boezem* city, from 1870 regulations about filling to *boezem* level come about and in 1902 these are legally implemented.[454]

In the report the difference between the old method of filling with dry material (brought in by ship, truck or train) and with wet material (hydraulic filling) is made clear. The wet method has some negative effects, like flooding in the surrounding area, and the larger scale of the heightening with a longer subsidence period means a delay in building activities. The choice for wet or dry is therefore often based on financial merits; the concern about the wet method is greater because using the dry method to raise the ground means that building can start sooner. The location of the building site is also a factor in decision making; when it is far from a waterway or difficult to build a rail, then the choice for wet is sooner made.[455]

For the study other cities such as Rotterdam, Delft, Vlissingen and Groningen are consulted even though different circumstances make

[453] Commissie bouwen op opgehoogden grond 1931, 3-4
[454] Commissie bouwen op opgehoogden grond 1931, 5
[455] Commissie bouwen op opgehoogden grond 1931, 15-16

comparison difficult. Rotterdam has the most comparable situation but conditions are worse there compared to Amsterdam since it is built on 8 m of peat and Amsterdam on around 4 m. Due to this, in Rotterdam the polder city type is used more often because using a thicker layer of sand will mean continuous subsidence. Even in these polder expansions subsidence occurs often and the costs of maintenance of streets are high. To solve this, the groundwater level is also lowered, but this can lead to pile foundations rotting when they stick out above groundwater level.[456]

The advantage of a *boezem* city is that filling offers a very stable basis on which to build. In the polder city the ground level is much lower and the 'cunet' method is often applied: under the streets the peat is dug away (to a depth of 1 m) and replaced by sand. This means that the location of the streets needs to be established much sooner than in a *boezem* city where they can be placed anywhere. The *boezem* city is the forerunner of the integral filling method.[457]

The sewer needs to be as deep as the groundwater level, which is usually 1 m under the street level. The cables need to be above the groundwater but deep enough not to be damaged by heavy weights and frost. Another important aspect of filling is material. Sand is the best choice since water passes easily through it. Within the city blocks this is especially important because no discharge on the sewer or open water is possible. When clay or mud is used as filling material this means that within the city blocks additional drainage is necessary and it is better to top the pile foundations with a concrete hat.[458]

The commission takes it even further and gives advice about the general expansion plan in the making. They consider water as a crucial element in the urban vista of Amsterdam; it is seen as a tradition that should be continued. This is, of course, a subjective opinion that is more difficult to defend than the fact that apart from this open water is also of use and necessary as a traffic structure, for hygiene (it caches dust and so cleans the air) and to store water to maintain the groundwater level. Especially in deciding whether to expand the city with a *boezem* or a polder city, the commission has a few considerations.

First of all, the existing buildings in the area that can be used for the expansion.

> In this time when so much effort is put into city expansions it is out of the question that developments that do not fit in the general plan are executed.[459]

The areas available for expansion are all at polder level (peat and clay polders). When realizing a *boezem* city all of the existing buildings (at polder level) need to be demolished, or expensive other measures have to be taken. When a *boezem* city is built it means that the city will be automatically

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[456] Commissie bouwen op opgehoogden grond 1931, 7 and 22
[457] Commissie bouwen op opgehoogden grond 1931, 23
[458] Commissie bouwen op opgehoogden grond 1931, 17
[459] In Dutch: Nu is het in dezen tijd, waarin zoveel meer zorg dan vroeger aan de stadsuitbreiding wordt besteed, wel uitgesloten, dat er nog complexen worden gesticht buiten eenig verband met het grootere geheel. Commissie bouwen op opgehoogden grond 1931, 31

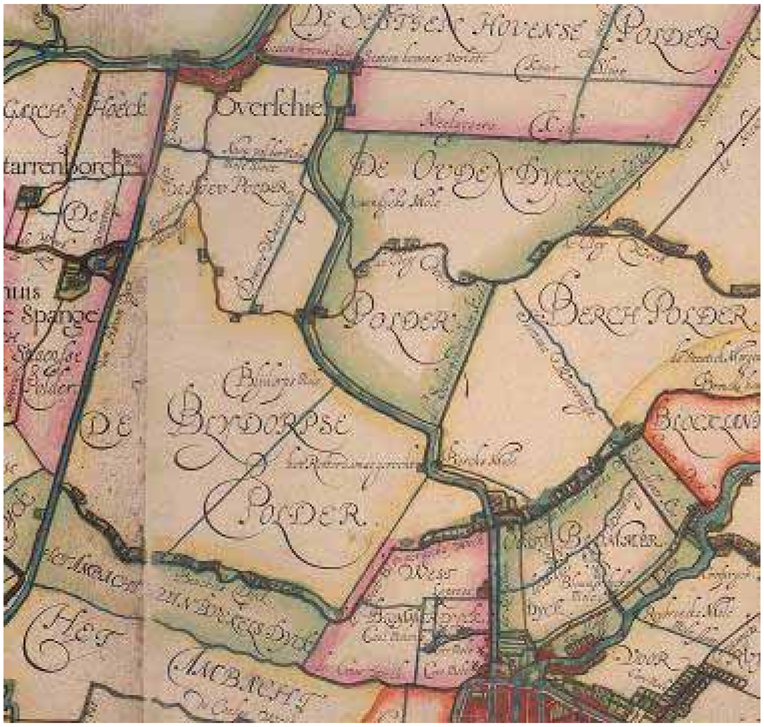
disconnected from the polder (it becomes an island); when a polder city is built a new polder is built for this city with all the spatial consequences, for example, surrounding dikes (that includes a special urban design challenge). The polder city then needs to be connected to the existing *boezem* city and this means dikes, bridges (with long ramps), sluices and large water surfaces with quays; not to mention the problems with connecting sewers, discharge, infrastructure and also the urban vista. In Amsterdam 60 per cent of the rainwater goes into the sewer because the surface is 'sealed' by buildings and pavements. According to the report there is 4 per cent open water in agricultural areas and in a polder city this should be at least 6 per cent for rainwater storage, regulating the groundwater level (therefore spread out over the area).[460] The surrounding waterways can be maintained at *boezem* level, also bringing large dikes into the city. The difference between the *boezem* and polder level can also be solved by placing green structures and recreational areas on the spot.[461]

The commission also analysed the financial difference between the *boezem* and polder city with the conclusion that a polder city is somewhat cheaper than a *boezem* city, even with the extra constructions, more space for water and the higher maintenance it requires afterwards. This has the effect that a polder city is more suitable for the building of ground-bound houses that take up more space. Compared to a *boezem* city with high-rise buildings for social housing a polder city with ground-bound housing is more expensive. In the case of a polder city, the commission advises the construction of more differentiated housing, ground-bound social housing and villas and high-rises along the most important infrastructure (connected public buildings, as are built in Amsterdam Zuid at that time). However, low-rise is considered too boring because the city vista needs some contrasting elements.[462] The final advice is to take the building of the polder city outside the rail ring very seriously and to complete the *boezem* city within that ring so the ring can form a good border.[463]

Rotterdam Blijdorp

The first dikes in Blijdorp area are constructed around 1170 to bring a tidal landscape under control. Another dike ring more to the south is built around 1220, the current Beukelsdijk and Walenburgerweg. This dike forms the polder named after the soggy ground *bri* or *brei* (meaning pulp or mush) *Bridorp* and eventually *Blijdorp*. The peat polder is covered with a layer of clay, sediment of the Maas. It is reclaimed with strip parcelling in a north-south orientation. Across this parcelling pattern an old creek, the Blijdorpse Wetering, remains as part of the main drainage system. The polder is very wet and used as pasture for cattle.

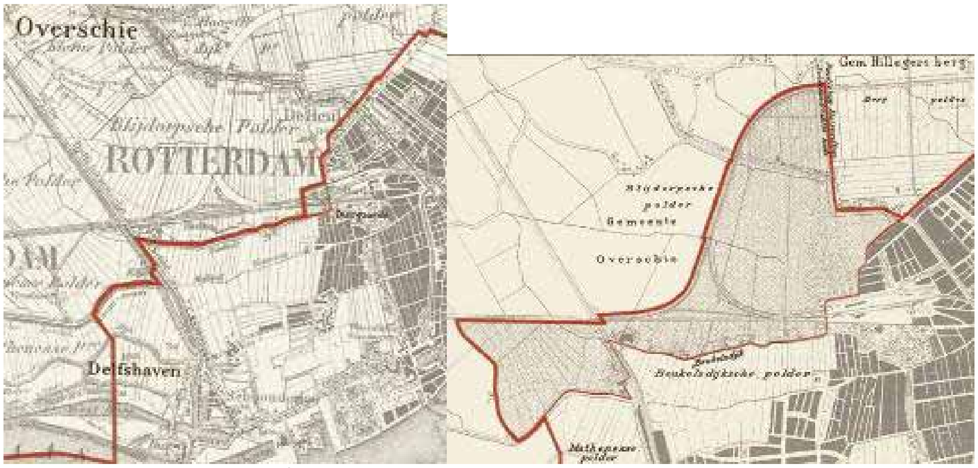
[460] Commissie bouwen op opgehoogden grond 1931, 25-26
[461] Commissie bouwen op opgehoogden grond 1931, 29-33
[462] Commissie bouwen op opgehoogden grond 1931, 52-56
[463] Commissie bouwen op opgehoogden grond 1931, 58



Picture 5a.10 Blijdorpse polder in the seventeenth century
Source: Municipal Archive Rotterdam

Between 1340 and 1348 the Rotterdam Schie is dug right through the polder to improve the transport of goods to the hinterland. Rotterdam is in competition with Schiedam for these markets. Not much later between 1389 and 1404 the digging of the Delfshavense Schie causes Rotterdam to win the battle. In the polder Blijdorp farms settle along the Rotterdam Schie and the Beukelsdijk, forming ribbons of houses. In 1899 the Ceintuurbaan (translated it means ‘belt road’) is built, which divides the polder Blijdorp into an eastern part, the urban area Blijdorp, and a western part that now houses the zoo, the jail, a harbour and different stores. This rail dike is constructed to make a connection between the southern railway line from Dordrecht and Belgium and the eastern line to Utrecht and Germany, for the transport of goods. Trains for transport of people start to use this line only after 1953 when the new central station is built and the Maas station closed.[464]

[464] Borselen 1993



Picture 5a.11 Annexation of the Blijdorpse polder in the nineteenth century
Source: Municipal Archive Rotterdam

Plan De Jongh

Increasing harbour activities bring a lot of people to Rotterdam and the demand for houses becomes increasingly urgent at the end of the nineteenth century. The city is still a small settlement in comparison to the huge harbour. The polder Blijdorp is empty, except for the ribbon of houses along the Schie. Just when two developers, Bouwmaatschappij Immobilia (in 1899) and Maatschappij Insulinde (in 1901), buy land and develop simple street plans that follow the polder structure, the Housing Act of 1901 and the pressing demand for housing arise. As required by the Housing Act the Director of Public Works G.J. de Jongh (from 1879-1910) has to make an expansion plan. Blijdorp is chosen as an excellent place for the working class and in 1903 one part is annexed from the neighbouring municipality of Overschie and in 1904 the other from Hillegersberg.

De Jongh's plan for the expansion in northern and north-western direction is not an actual 'plan', but more the registration of what is on the table at that time. De Jongh, and the municipality, regard urban design to be of minor importance, or better, subservient to building the harbours of Rotterdam, and therefore best left to private developers.[465] The proof of the matter is that De Jongh anticipates the building practice by simply including the plans of Immobilia and Insulinde in his expansion plan.[466]

[465] Van Ravesteyn 1948, 148
[466] Tijdschrift voor volkshuisvesting en stedebouw 1929 no. 9 10e jaargang september, 169

Picture 5a.12 Plan for Blijdorp by G.J. de Jongh, the white spots in the circle are plans of the private developers.
Source: Municipal Archive Rotterdam

De Jongh's general plan is approved by the Council on 29 March 1906. It is an overview of the challenges the city is looking at. The harbours, rail and roads, annexations and projects of the private developers all add up to the practical plan. It shows that the city has to think about its regional position as well as the consequences of this on the scale of the neighbourhood. In the detailed plan for Blijdorp all these regional demands play a role: the canal (transport) system, the road, the housing issue and dealing with annexation and building-site preparation. In the plan the Schie is maintained as an important water artery, the regional rail and road connections are considered. In the drawing the white areas are the projects of Immobilia and Insulinde and the subdivision of the land is done with an economical use of space. The main issue of the plan is the connection to the city centre. This is difficult because the railway blocks every entrance. De Jongh makes several plans for high bridges over the railway, all too radical for the Council. The burgomaster mr. A.R. Zimmerman finally has the idea of using the tunnel of the watercourse, the bypass of the *Waterproject* that connects the Diergaardesingel with the Stationsingel. The water is put in a sewer under the new road in 1915; Van Ravesteyn calls it a 'metamorphosed sewer'.[467] It is one of the many interventions that destroy the unity of the *Waterproject singels*.

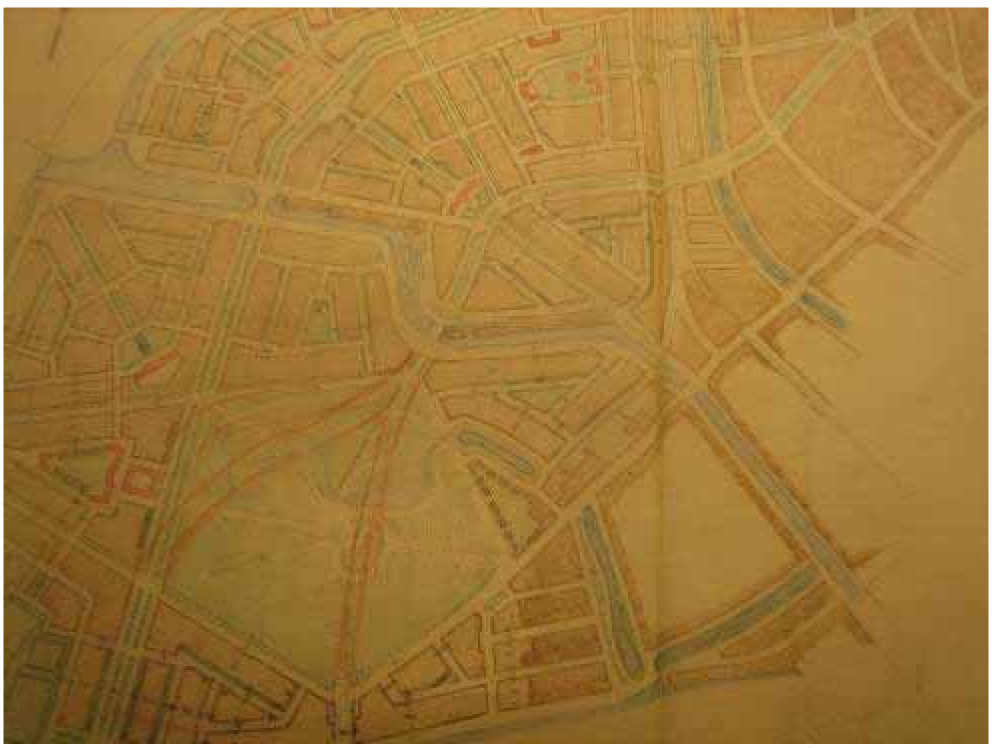
Plan Verhagen

Just before De Jongh leaves Public Works in 1910 he makes another plan that alters the expansion plan of Blijdorp significantly: the Channel Plan. Due to the fact that several moats in the inner city are filled in, water

[467] Van Ravesteyn 1948, 183

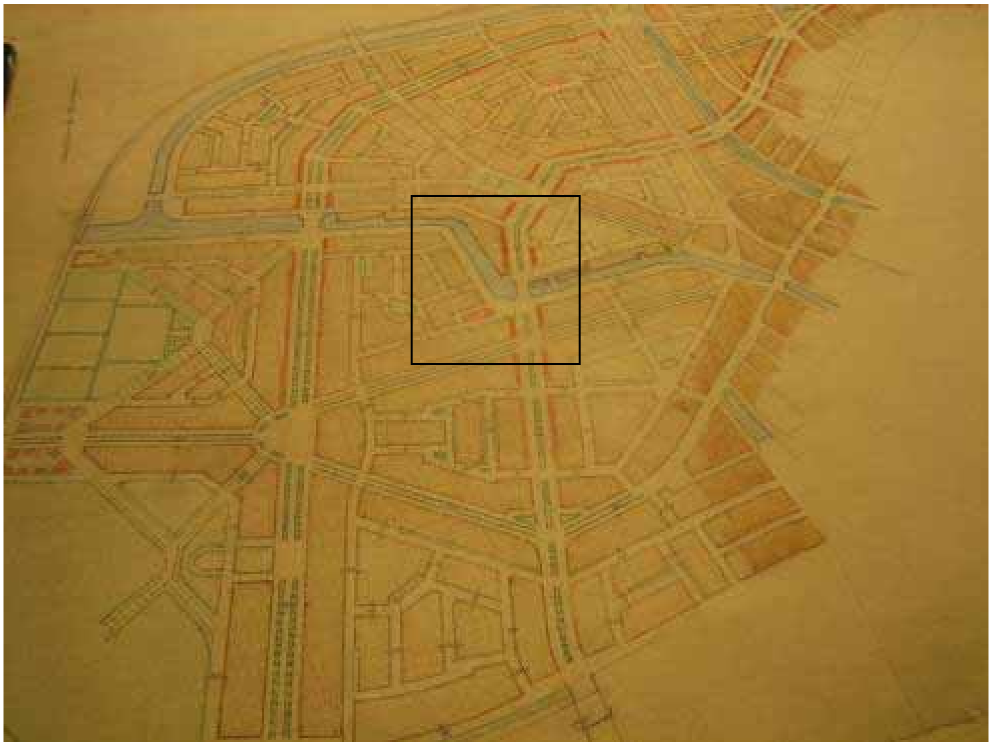
transport routes run into capacity difficulties. At the same time a park in Kralingen is planned and a channel is necessary to transport the needed soils (from the Waal Harbour). The Northern Lake is (after the Alexanderpolder is drained) the rudiment of the peat lake landscape and with soil that came from excavating the Waal Harbour it is turned into a lake, park and forest. For the transport of this soil De Jongh proposes to make the connecting channel between the Rotte, Schie and Delfshavense Schie. It turns out later that the technology of hydraulic filling is much easier and cheaper so the channel is not necessary, but the plan remains.[468]

The urban design for Blijdorp not only needs to be revised for the channel but also to meet the demands for a park and sport facilities that are stronger under pressure of the Board of Health. De Jongh's successor A.C. Burgdorffer (from 1910-1923) and municipal urban designer Piet Verhagen[469] draw up new plans that anticipate these questions. In the Rotterdam Archive different sketches are in the portfolio showing the study of how to incorporate the park, the infrastructure (road to The Hague and the channel) and the programme in the plan.[470]



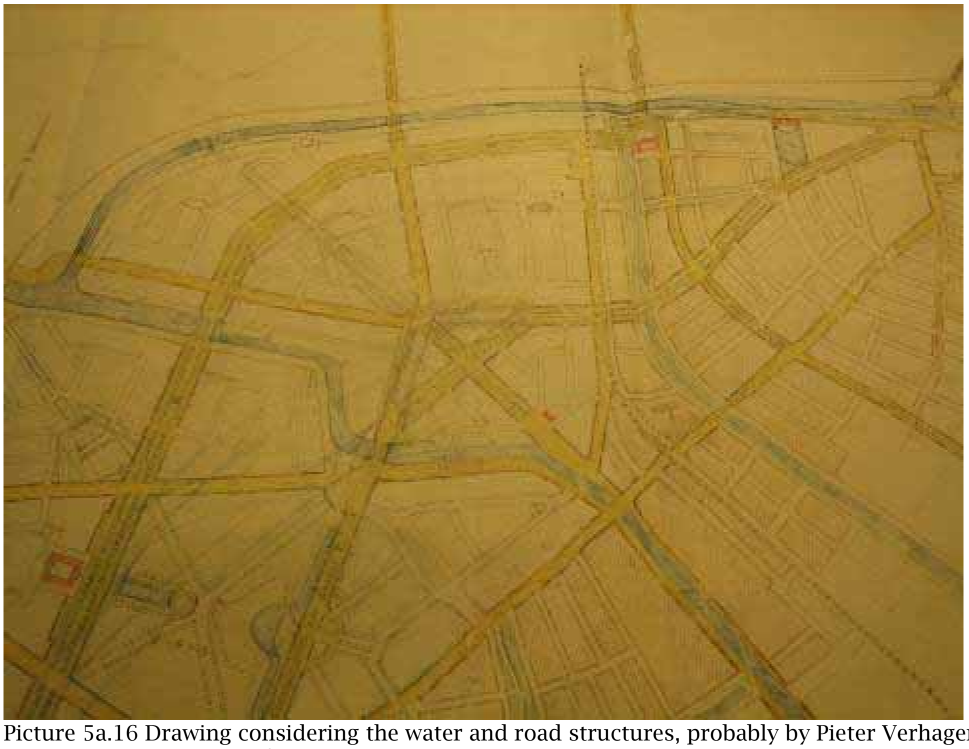
Picture 5a.13 Drawing probably by Pieter Verhagen, was in the Commission of Public Works 1 December 1913
Source: Municipal Archive Rotterdam

[468] Van de Laar 2000, 288
[469] Steenhuis 2007, 96
[470] Inventarisnr. 1464, ingekomen stuk 4719 in 1913



Picture 5a.14 a and b Drawing without the central park and a detail of the bridge over the Schie where he, like in dam cities, proposes to situate the church. Probably by Pieter Verhagen, and handled in the Commission of Public Works 1 December 1913
Source: Municipal Archive Rotterdam

Picture 5a.15 Drawing with central park and water structure, probably by Pieter Verhagen, was in the Commission of Public Works 1 December 1913. The watercourse of the Waterproject, the Spoorsingel, is extended into the plan as element in the park.
Source: Municipal Archive Rotterdam

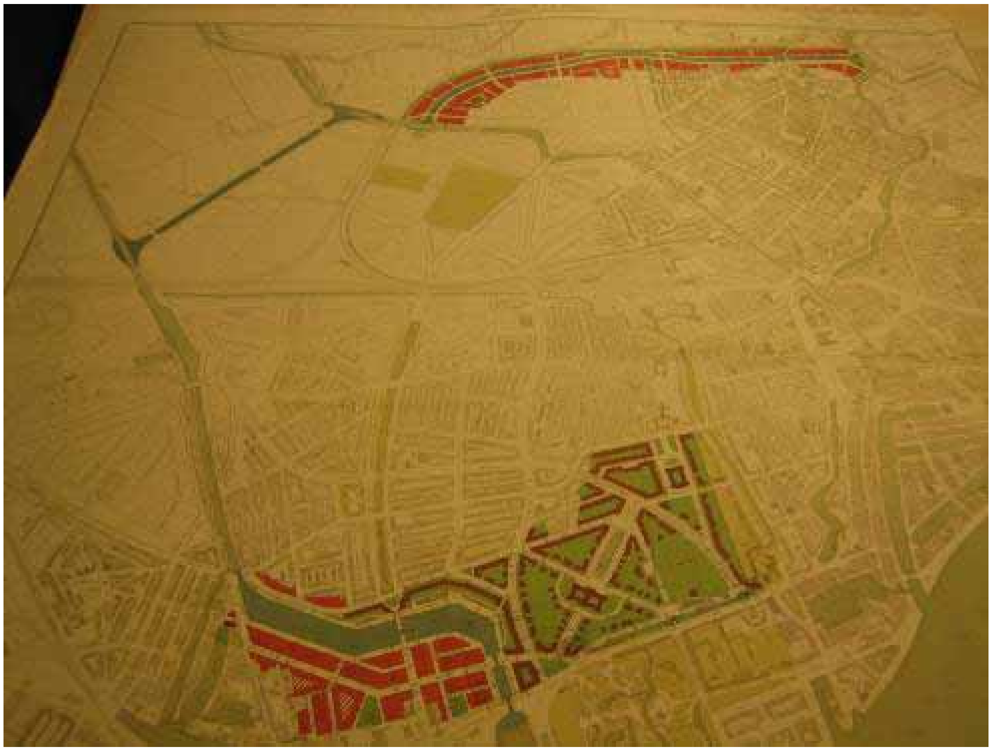


Picture 5a.16 Drawing considering the water and road structures, probably by Pieter Verhagen, was in the Commission of Public Works 1 December 1913
Source: Municipal Archive Rotterdam

Picture 5a.17 Final drawing, probably by Pieter Verhagen, was in the Commission of Public Works 1 December 1913
Source: Municipal Archive Rotterdam

The final plan is presented to the Council (and is accepted on 6 May 1915)[471] as being adaptive to the Channel Plan (that is presented on 12 November 1913) and providing an infrastructure that will guarantee proper connections in the future.[472] The streets of the existing city are connected fluently through the new urban area. Radial streets in combination with squares and parks make for a pleasant urban plan wherein the subdivision is not a copy of the polder structure, but the larger sized blocks emphasize the street structure. The curve in the Schie is used to make a monumental square in the plan where different streets come together. Besides the Schie, an extension of the Noordsingel of the *Waterproject* and the new channel along the Ceintuurbaan, no other water structures are taken into the final plan.

[471] GAR, 6 mei 1915 raadsbesluit rapport 9/9/1916 ingekomen stuk 3335
[472] GAR, Archief Publieke werken inventarisnr.1472, ingekomen stuk 1926 in 1914, Directeur gemeentewerken Burgdorffer aan de Cie Plaatselijke Werken

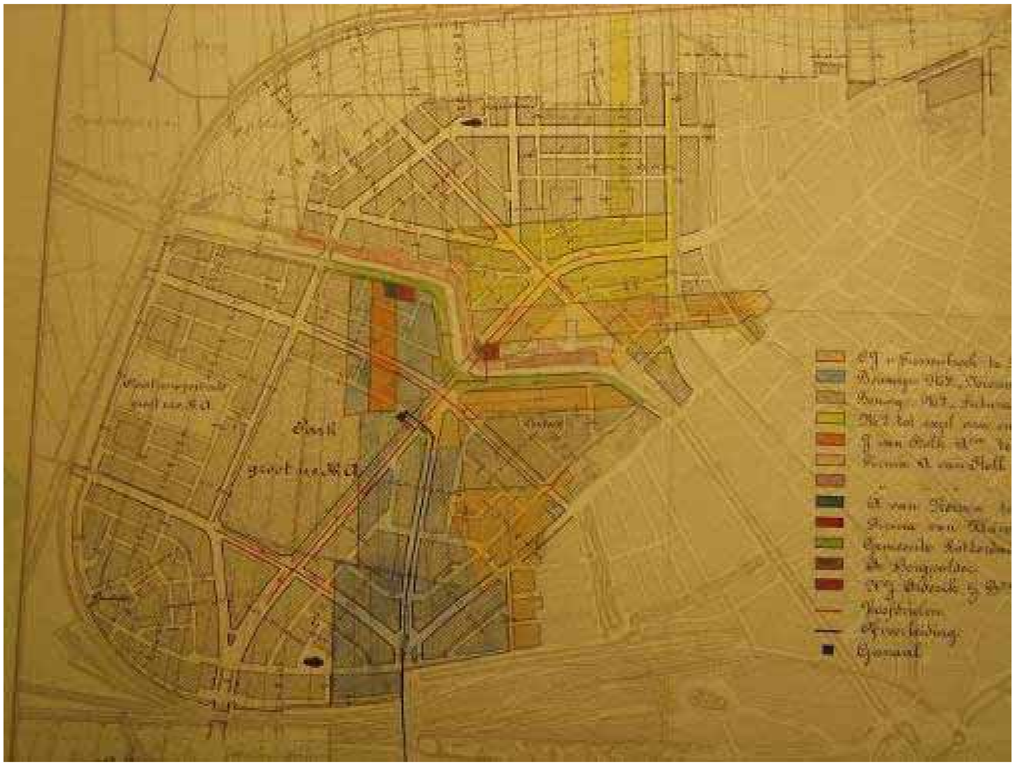


Picture 5a.18 Channel Plan 1918, approved in 1920
Source: Municipal Archive Rotterdam Tek 3944, 4J 1918,

The connecting channel is drawn in the northern part of the plan, going through the projected industrial area. The Board of Health strongly opposes the situation of industry in the residential area. A thorough study by the Board (1915) into the municipal ground politics shows little effort to produce residential areas.[473] At the beginning of the twentieth century the private developers draw back from development. It becomes increasingly difficult to answer the demands of the municipality, the higher costs imposed for city improvement and pumping (first 30 cents per square metre, later 1.30, rising to 2.40 and 3 guilders). This leads to the situation that in 1913 there is a great shortage of sites on which to build the desperately needed housing.[474] Also the building on the left bank of the Maas increases. This signifies an important development because as long as there are enough sites on which to build on the right bank no development is done on the left (too far away from the city). In 1916 when no building sites are available because the First World War causes a shortage in foundation piles, the development on the left bank starts because there, on the clay, houses without piles can be built.[475]

[473] Health Board was disassembled in 1933, they advised how to solve the questions about industry in Blijdorp, jaarverslag 1914 p, 30, 33, 34 p 39
[474] Van Ravesteyn 1935, 8
[475] Van Ravesteyn 1935, 32

The report of the Board of Health suggests how the ground policies of the municipality can be improved and applied to Blijdorp to be able to answer to the demand for building sites for different purposes.[476] For Blijdorp this means that the development of good housing for the working class should start as soon as possible.[477]



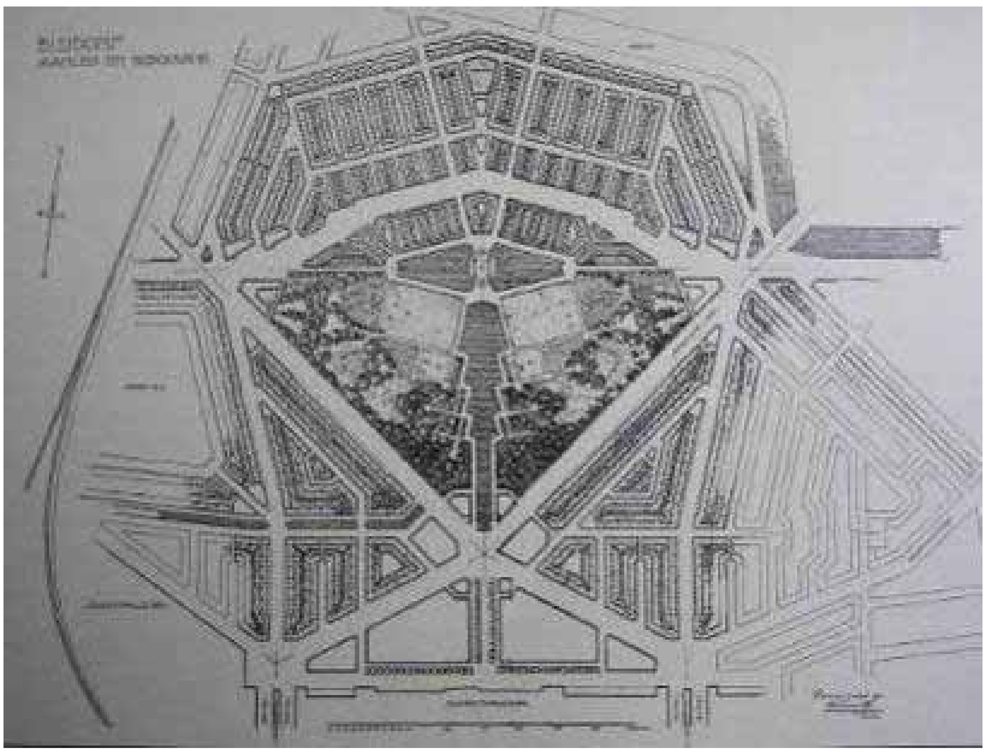
Picture 5a.19 The colours represent the patchwork of landownership
Source: Municipal Archive Rotterdam 2810, 4FI, 1915

The new design does not include the plans by the private developers. The Department of Public Works becomes the mediator between all the owners to make them cooperate in realizing the plan. Because this has been very difficult in the past, and there are many owners in Blijdorp (only the park area is owned by the municipality), Council member architect J. Verheul proposes to expropriate the whole area and develop the plan before selling the lots to builders.[478] Between 1904 and 1914 the municipality buys large parts of Blijdorp and in 1920 the procedure of expropriation is started. The whole polder is in the hands of the municipality by 1923. Besides land the municipality also has to buy the 'right of wind'. Schieland Water Board owns these rights for their pumping stations (mills) in the polder.[479] In 1922 the municipality takes over the Blijdorp pumping station from the Schieland Water Board. All the plans incorporate this pumping station as part of the

[476] Van Ravesteyn 1935, 34
[477] GAR, Jaarverslag gezondheidscommissie 1915, bijlage IX
[478] GAR, Archief Publieke werken inventarisnr.3632, ingekomen stuk 3669 in 1918
[479] Van Ravesteyn 1948, 172

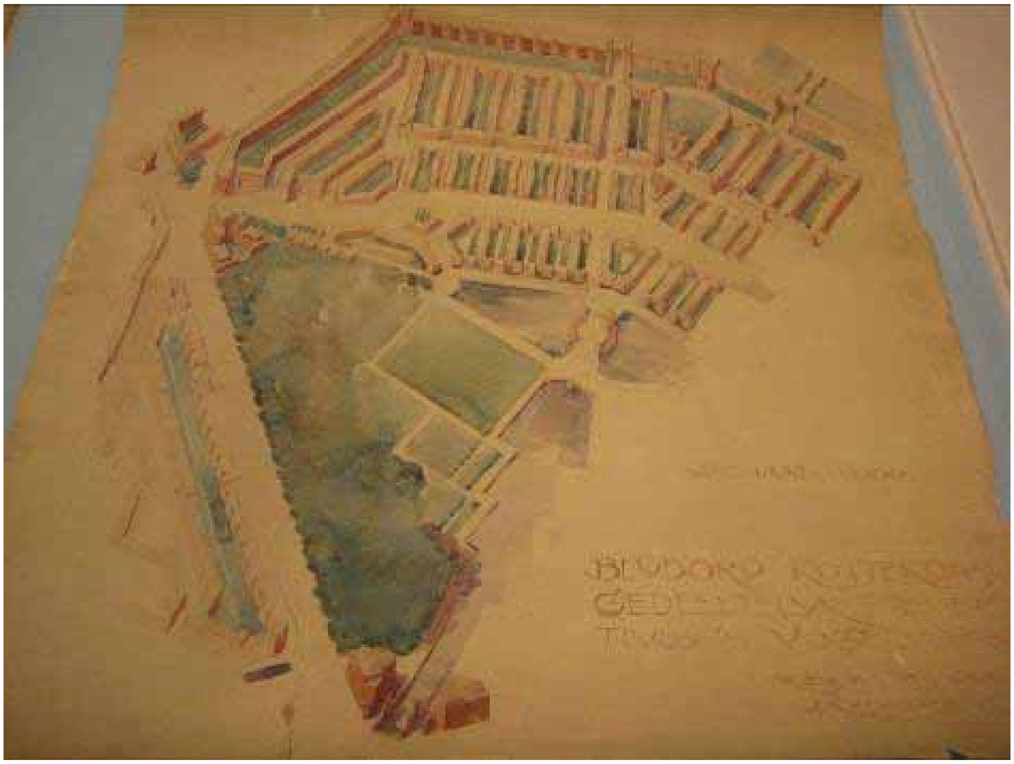
new urban (underground) water system (visible on the drawing showing the property owners above).[480]

In 1919 the Department of Public Works reports problems with the soil: the question of the groundwater table in Rotterdam. It states that the problems with the soft and weak soil can be solved by applying a layer of sand, preferably spouted up. That will put proportional pressure on the peat and offer a steadier layer to build on. The streets do not need to be raised and also sewers will be stable in the layer of sand. The new approach will have the advantage that partial subsidence, and partial maintenance, will not occur because the whole area will subside evenly. The building costs are higher but the maintenance costs will be lower. Also the groundwater table does not have to be lowered which is better for existing foundations.[481]



Picture 5a.20 Plan by Kromhout in 1920.
Source: Anonymous no date

[480] GAR, Archief Publieke werken inventarisnr.1628 ingekomen stuk 3986 in 1922
[481] Moscoviter 1996, 73



Picture 5a.21 Plan Kromhout isometric
Source: NAi Archives J.B. Bakema, nr. T91

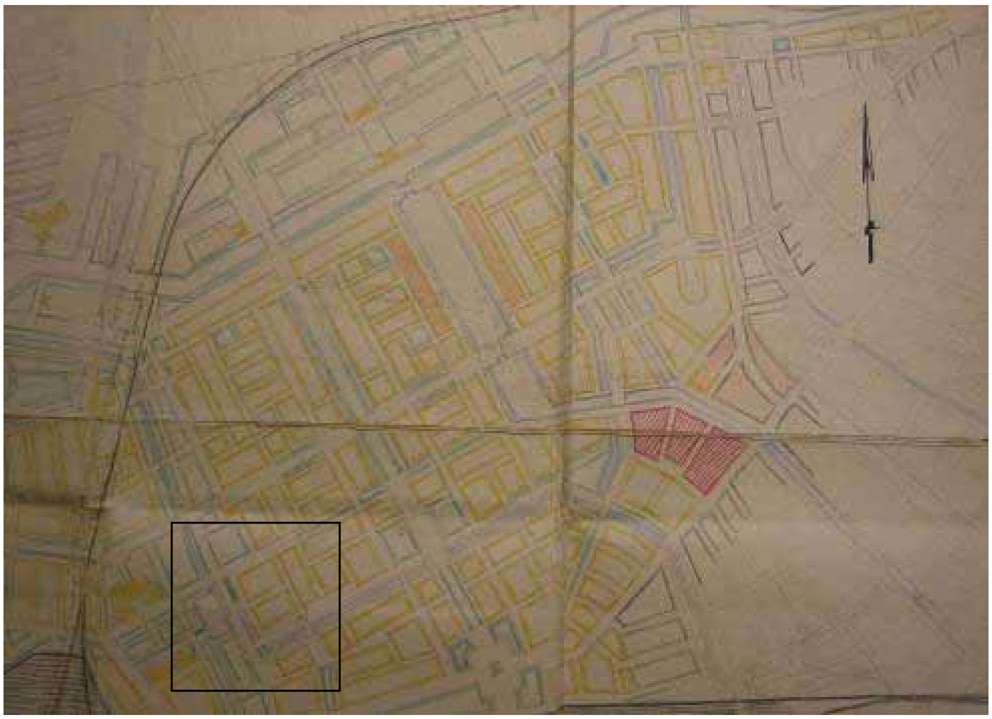
Plan Kromhout

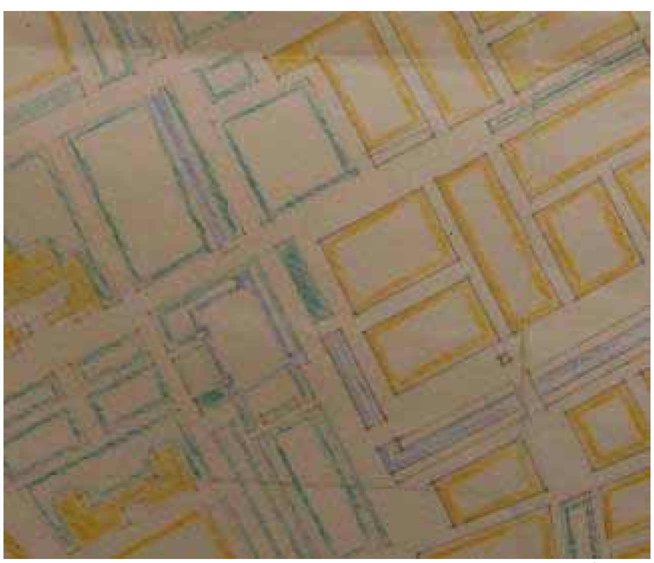
Five years after approving Verhagen's plan, in 1920 the municipality assigns architect W. Kromhout to design 2,500 houses, taking into consideration the plans for a new central station in Blijdorp, a park and sport facilities. Again time is overtaken over by regional developments that outdate the plan of 1915. Kromhout does more than make a simple plan; he makes an aesthetically idealistic urban design under the influence of the left-winged alderman Arie Heykoop and the director of the Municipal Housing Department ir. A. Plate. The Council approves the plan in 1924 but it is never realized as such.[482]

The symmetrical plan covers a park in the centre where a pond is used to emphasize the symmetry. Kromhout makes a connection to the Spoorsingel (of the *Waterproject*) and a connection from the central park pond to a (undefined) water structure on the west side of the plan. However, in this urban design water does not play a structuring role, but is used as an aesthetic element. The original polder structure disappears. The decision to spout up a layer of sand to a level of 0.40 m -RP[483] is approved by the Council on 23 November 1924. Like Verhagen, Kromhout uses the curve in the Schie as a situation to make a monumental and connecting square. The Schie borders the plan because it is also the border of the water management unit (the polder). It could be raised with a layer of sand as a unit and the existing pumping station could be used for drainage.

[482] Tijdschrift voor volkshuisvesting en stedenbouw 1929 no. 9 10e jaargang september, 169
[483] R.P. is Rotte Peil Which was 60 cm below NAP Nieuw Amsterdam's Peil or Mean Sea Level

That times are changing fast is illustrated by the fact that all railway plans are withdrawn. The new head of the Department of Urban Development and Building since 1924 (and in 1926 promoted to city architect) W.G. Witteveen considers Kormhout's plan outdated in 1927, after the site has already been prepared with a layer of sand. One of the arguments is that the symmetry of Kromhout's design detracts from the new situation of the central station along the Essenburgsingel at the W.G. Burgerplein. The station is going to be more to the east so the symmetry has lost its meaning.





Picture 5a.22 Plan Witteveen and detail showing the carefull ensemble of buildings (yellow), public space (green) and water (blue).
Source: Municipal Archive Rotterdam

Plan Witteveen and Kromhout

The new director of public works H.S. de Roode (from 1923 to 1928) writes in 1927 in the letter accompanying Witteveen's plan that due to the Channel Plan, the railway puzzle and the new highway to The Hague, yet another new plan is needed. No remarks about water management are made, but there are many more *singels* projected in the plan.[484] Not only the Spoorsingel is extended**,** two other *singel* structures with a north-south orientation are also part of the plan. The Noorder Channel is altered because the industrial functions are removed from the area, according to the wishes of the Board of Health; the area is strictly residential. The most striking aspect of the plan in relation to the channels is the (partial) filling of the Schie, which is redirected into the Noorder Harbour, and then the Noorder Channel.

In the explanation one paragraph is devoted to the description of the chosen groundwater level. Filling in the area with a layer of sand will bring the streets to 0.40 m -RP. Along the Schie (which will eventually be filled in) the quays need to be on the level of 1 m above RP and the quays along water connected to the Rotte 0.50 m above RP. The sluice between the Schie and the Rotte will be situated as much to the west as possible. In the paragraph entitled 'pumping', De Roode writes that the area is a separate pumping district, using an electrical pumping station that already exists.

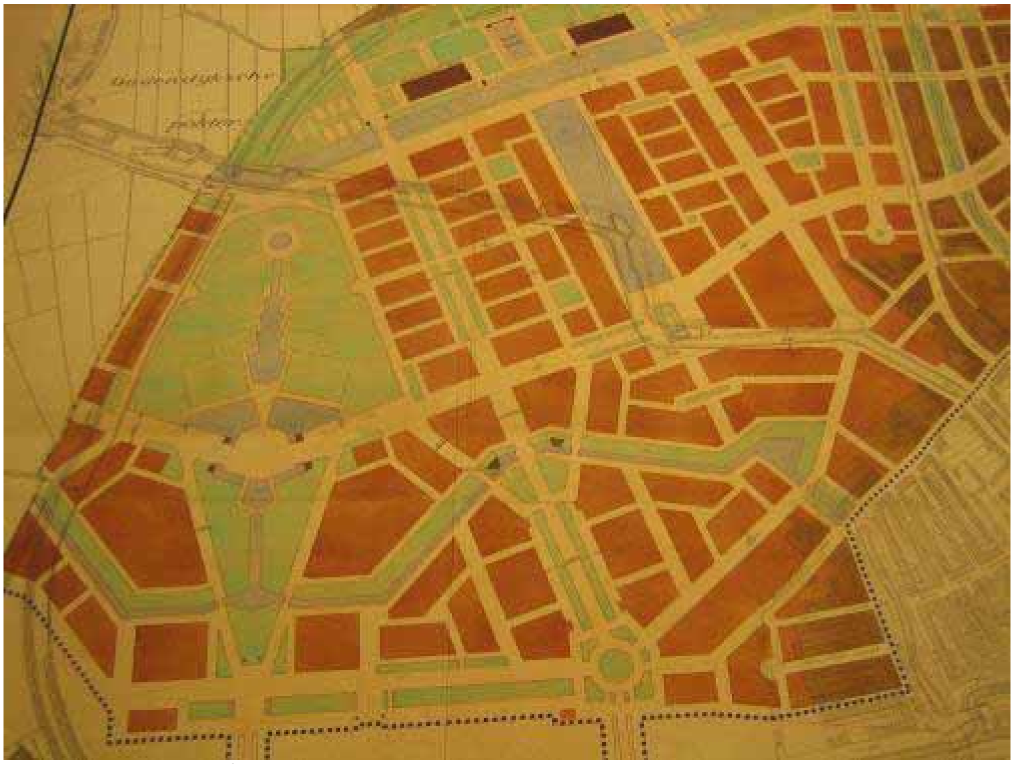
The Housing Committee is very surprised about the plan made by Witteveen. They think it is aesthetically inferior to Kromhout's design because it emphasizes infrastructure and pays little attention to parks and monumental design. The commission proposes to have the architects work together, an idea the Council adopts, and a meeting with Kromhout, Witteveen, De Roode, Council member Heykoop and alderman of Public Works De Jongh is organized at the town hall.[485]

In February 1929 the new urban design by Witteveen and Kromhout is presented to the City Council. It is a combination of both former plans: Kromhout's design is altered with better infrastructure (road, rail and water) and Witteveen's plan gains monumentality and parks. The technical elements, ground level and pumping stations, are taken from Witteveen's plan. Also, the water systems of both plans are merged: the Spoorsingel is extended and structures the plan from east to west, connected to the symmetrical pond in the park. The water structure forms a shadow of the main road structure of the area.[486]

[484] GAR Archief 294.01 inv 2362 dossier 456 -1 1927

[485] GAR Archief 294.01 inv 2362 dossier 456 -3 1927, Directeur gemeentewerken aan de wethouder van plaatselijk werken 29 juni 1927

[486] GAR Archief 294.01 inv 2362 dossier 456 -7 1927, Brief van directeur gemeentewerken aan de wethouder van Plaatselijke werken De Jong, feb. 1929



Picture 5a.23 Merge of ideas: Plan Kromhout and Witteveen.
Source: Municipal Archive Rotterdam

An important element of Kromhout and Witteveen's plan is the aim to reach unity in the architectural development of the plan. With the sale of the lots particular conditions are set up, for example function, envelope, number of houses in a block and the width of the houses, in order to achieve the desired harmony. This is possible for the first time because the whole area is developed at once. The fact that the municipality has bought the land and raised it with a layer of sand means it can be realized in unity. Moreover, the site preparation is finished before this final plan (which is largely realized) is even designed. The technology of hydraulic filling makes it possible to change the plans without any consequence.

Watery Construction

Between 1923 and 1928 the Blijdorpsepolder-east is hydraulic filled in with a layer of sand, clay and (sometimes) peat, dredged from the Merwe and Waal harbours. The 3-m layer is spouted up in several sessions in five compartments. In 1926 many technical details are discussed with different departments. The director of Public Works writes to the alderman of Public Works on 11 December that the building-site preparation of the northern side of the polder, above the Schie, can start. The polder on the south side of the Schie had been raised with a layer of sand in the past year (since the decision to raise the ground is made in 1924). The polder surface is 1.60 to 1.80 m below RP, thus a layer of sand of 1.20 to 2.80 m is necessary to reach the desired height of 0.40 m above RP for the building sites and from 0.50 to 1 m above RP along the waterways. Because the filling alters the water system, different adjustments are necessary (and permission of the polder boards is asked).[487]

On the picture the Oudendijkse polder (on the west side) will be closed off from the original outlet because of the Ceintuurbaan. The Bergpolder (on the east side) has an electrical pumping station, situated at the south end of the Scherpendrechtschekade. The polders will become one compartment and a new connecting ditch and pumping station is needed. The road that is situated on the Scherpendrechtsekade (a dike) has to be rerouted for all the cyclists that use that road on Sundays. The brown line in the picture at the north point of the Bergsingel is the new connection. The red line is the dike that formed the compartment that will be raised. The profile of the dike is as usual the inner side 1:1 and the outside 1.5:1, the top had to be at RP level. The yellow line is the pipe that spouted the sand from the Driehavencomplex, the same one that is used to raise the southern part of the polder. Because the Driehavencomplex is quite far away, 6.5 km, an in-between station will be necessary next to the Bergpolder pumping station. From there the return water will be pumped to the pumping station at the north end of the Heemraadsingel, built for the filling of the southern part of the Blijdorp polder.[488]

In relation to the filling of the area the building inspector has other details to think about; he has to make sure, for example, that the height of the different parts of the area will not result in any problems. The height difference in the streets that are perpendicular to the water structures (where the ground level is higher), for insance, can be solved by building blocks along the streets, and by not situating blocks perpendicular to the streets because that is more expensive.

The tradition in Rotterdam to have backyards (within the building blocks) on a lower level then the streets is also addressed. The 'cunet' method only raises streets and buildings, leaving back gardens low and usually very wet. This tradition is also a result of building the ground floor 1 m higher than the street, leaving room for basements that have a small window at street level and at the same height as the backyard. Besides the fact that the wet gardens, and the wet basement, are bad for health, the relation between the living room and the garden is zero; you have to stand in front of the window to see the garden. The building inspector proposes to raise the backyards as well and have requirements about building basements that are used for living. Thus it is decided not to make strips of sand on the layer of sand under the roads but to raise the entire area.[489]

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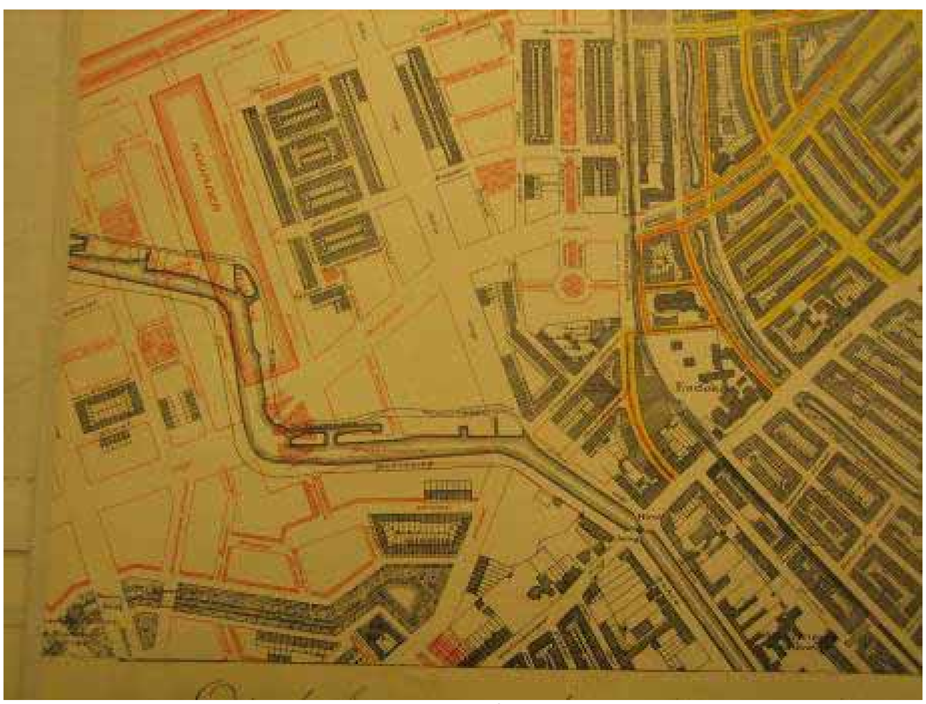
[487] GAR Archief 294.01 inv 2353 dossier 238-56 1927, Brief dir gw aan weth pl wer 4 mei 1928
[488] GAR Archief 294.01 inv 2353 dossier 238-1 1927dir gemeentewerken aan de wethouder plaatselijke werken 11 dec. 1926
[489] GAR Archief 294.01 inv 2362 dossier 456 -2 1927, Directeur van de bouwpolitie reageert aan de wethouder voor de sociale belangen.

Picture 5a. 24 Technical plan of the filled area, the brown line at the north point of the Bergsingel is the new cycle connection. The red line is the (loswalkade) dike that forms the compartment that will be raised. The yellow line is the (persleiding) pipe that flushes the sand from the Driehavencomplex.
Source: Municipal Archive Rotterdam

In a letter the director of Public Works De Roode applies for funding from the alderman of Public Works to continue the test of the load-bearing capacity of the piles in the Blijdorp polder. Because there is not much experience with the load-bearing capacity of piles in the spouted up layer of sand, a test is started in 1925. For this test two piles are driven into the ground. The first touches the border between the layers of clay and sand. Ten tons of weight is placed upon it. Not much subsidence is observed until the layer of sand is spouted up, after that the subsidence is so severe that the weight has to be removed. Even after that the pile still sinks; it doesn't stop until the subsidence of the layer of sand stops. In the letter the director finds it interesting to test the pile again and see how much it can bear. The second pile is put in the ground with its tip in the sand and is weighed down by 30 tons for a year. After the layer of sand is spouted up; the subsidence is 3 cm, while the subsidence of the layer of sand is 22 cm. The weight is reduced to 25 tons and Public works applies for funding to find out at what weight the subsidence stops.[490]

[490] GAR, Archief Publieke werken inventarisnr.1768, ingekomen stuk 1803 in 1927, Brief directeur der gemeentewerken aan de wethouder van plaatselijke werken

Picture 5a.25 This map belongs with a letter from the director of Public Works and shows the state of activities on 27 June 1930. The phone company complains about the sand blowing into their switchboards. The solution is to inundate the area, due to the fact that the area had irregular heights it is difficult to use the most common method of putting a layer of mud on top or grow grass.
Source: GAR Archief 294.01 inv 2353 dossier 238-83 1927, Kaart behorende bij brief dir gw aan de wethouder pl werken 27 juni 1930



Picture 5a.26 This map shows the complexity of the project with old and new water structures, old and new urban blocks and in yellow streets to be filled again.
Source: GAR Archief PW 5201 4IJ 1933

The subsidence of the sand layer is also much higher than expected, again showing the inexperience of the Department of Public Works with this method. There is much more sand needed than is calculated, due to the bad quality of the territory: wet and soft. Not only is the amount of sand important in calculating costs, so is the place from where it has to come. The national government is in charge of pointing out the areas where sand can be excavated. The director of Public Works complains that it had to come from too far, the Oude Maas, thus driving up the costs.[491]

Since the hydraulic filling is much easier than spreading the sand with vehicles, the director proposes add another layer of 50 cm. The area is divided into five sections; this means that for sections A and B 500,000 to 600,000 m^3 of sand is necessary to bring them up to respectively 1 and 1.5 m above RP and for section C 200,000 m^3 sand. Since no dwellings with basements will be built, the backyards also need to be raised.[492]

Urban Tissue

Even though it may be less obvious, an important influence of the Housing Act is the establishment of housing cooperatives. The law provides government money to make these cooperatives possible. This means that the scale of development grows and larger blocks are built with housing for the lower social classes. Again the industrialization of the building practice (as with the development of the hydraulic filling) makes this conveniently possible.

The influence on the urban tissue is also an enlargement in scale. Instead of individual houses, urban blocks are built as apartment buildings. The size of the blocks becomes larger and the first open building block is realized in Blijdorp. In the final plan the difference between the polder city (alongside the *Waterproject*) and the new raised Blijdorp is remarkable. In the polder city the original polder structure is used to dimension the urban blocks that are built up out of individual houses. In Blijdorp the infrastructure is used to make the overall layout of the plan and the water structure (connected to the *singel* of the *Waterproject*) goes diagonally through the area providing a green lung that is connected to the park. The other water structure is the Noorderkanaal and its harbour, Noorderhaven. This water structure forms the border of the area on the north side; the western border is formed by the railway line to Gouda and Utrecht. The park and larger parts of the area are set up in a symmetrical manner. In the park the water structure is used as the backbone of symmetry, in the residential area especially the Statenweg is the axis used to mirror the urban tissue.

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[491] GAR Archief 294.01 inv 2353 dossier 238-78 1927, Br dir gw L.W.H. van Dijk aan weth pl wer 11 okt 1929

[492] GAR, Archief Publieke werken inventarisnr.1889, ingekomen stuk 12.034 in 1929, Directeur gemeentewerken aan de wethouder van plaatselijke werken

Picture 5a.27 Final plan that is for the larger part realized
Source: Municipal Archive Rotterdam

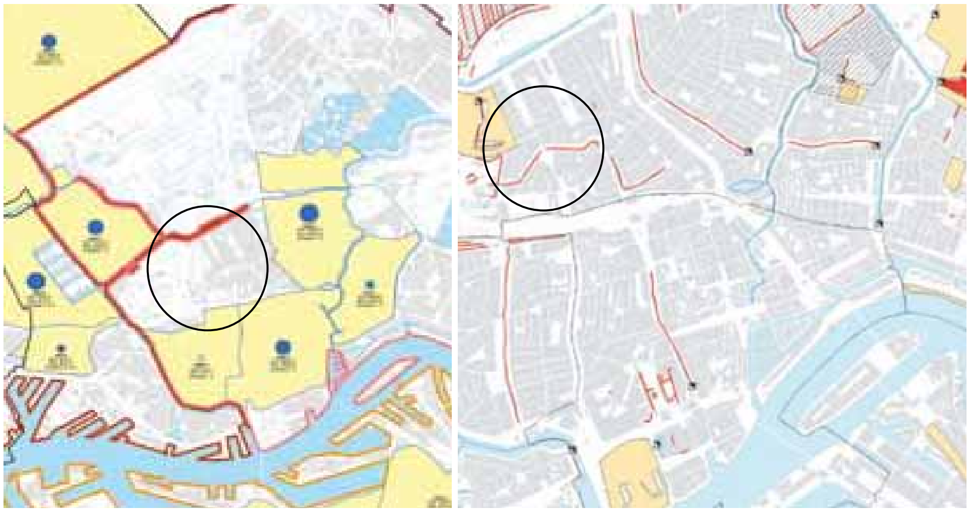
Blijdorp in 2011

In 1931, just when the lots are put on the market and the selling is going well, alderman A. van Kranenburg is relieved:. . . after a very long time we can finally change the sand desert, called Blijdorp, into a fine, spatial and modern new part of the city.[493] The novelty of developing a whole new area as a municipality has taken a very long time. Even though the method of preparing the site enables the plans to be changed all the time, by January 1927 even the bookkeeper of the Department of Finance wonders if it is possible to decide about the street layout before starting to spout up the area. The street layout of the first site in Rotterdam to be spouted up, the land of Hoboken, was made before the land was prepared to build on, so that rent on the lots could be collected. In other words, financially the time it has taken to develop Blijdorp is a disaster.[494]

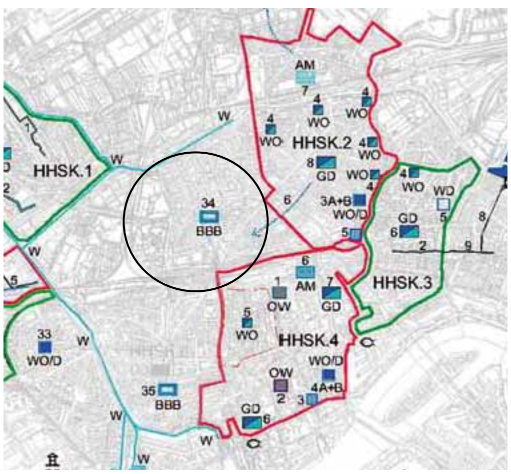
Between 1931 and 1939 the Schiekanaal (Schie Channel) and the Noorderkanaal (Noorder Channel) are dug as a 'bypass' for the Rotterdam Schie that is going to be filled in.[495] For the same reason the Noorder harbour is built in 1931-1932, and again filled in 1942 because the traffic over water is not as expected and the grounds are needed to build schools.[496] The first

[493] In Dutch: '. . . na zeer lang wachten eindelijk de zandwoestijn, die Blijdorp heet, zullen kunnen gaan veranderen in een goed en ruim aangelegd en van moderne opvattingen getuigend stadsdeel.' GAR Handelingen der Gemeenteraad 26 maart 1931, pp. 141-163.
[494] GAR Brief van de administrateur der afdeling financiën aan de wethouder van financiën, 26-1-1927
[495] GAR Kanalenplan verschijnt in 1918, verzameling 1917 no. 263 en 1914 volgnr 59 raadsbesluit 5 sept 1922 tot onteigening p38
[496] GAR SO 3 1942

part of the Rotterdam Schie that flows through Blijdorp is filled in with sand. In 1940 the Schie is completely filled in with rubble from the destroyed city centre. On this tract the important traffic artery Schiekade is built.



Picture 5a.28 In Blijdorp there no water issues but there is a quality issues.
Source: Waterplan 2



Picture 5a.29 Blijdorp can serve as catchments area for problems in the neighbouring districts.
Source: Waterplan 2

As planned the area becomes a residential area without too many urban functions. A few shopping areas provide for the basic needs of the residents. The public space and the water structure are well maintained and form the green lungs in the area. Most of the park is taken up by the Rotterdam Zoo Blijdorp, which moves here from the inner city after the Second World War. The northern part is the Vroezepark, which is very well used by the residents.

There are no problems in Blijdorp concerning water management since there is no water quantity issue, only a water quality issue. Moreover, in Waterplan 2 Blijdorp is appointed as a catchment for the neighbouring areas when needed.

The Fine Dutch Tradition: Episode Four

While the functional meaning of water increasingly recedes, ‘nature’ in the city gains proportional interest. Around 1900, under the influence of Boards of Health established to protect the hygienic interests of the city, the demand for more public green spaces increases. Besides traffic, buildings and water, a new element in the city structure is introduced: public areas. At the same time, structures of buildings, traffic and the combination of water and green spaces are separated. These structures coincide in traditional cities, such as in the Amsterdam ring of canals, where one single main structure contains all the elements.

At the beginning of the twentieth century it appears that water and green spaces can only guarantee their right to exist if they are combined. Water is part of the green structure, and the green spaces acquire rights as public areas as components of water. At first the combined structures of water and green areas are of importance and form the backbone of the city design in combination with the structure of traffic. In Plan South (1915) in Amsterdam and in Blijdorp (1931) in Rotterdam, the structure of public areas and water (which can also be sailed on in Amsterdam) follows a displaced shadow of the traffic structure. Then, as well as now, the urban composition becomes a derivative of the traffic structure and accessibility principles due to the importance of motor vehicle traffic.

The accelerating powers of industrialization are influencing technology, economics and society and urban form. This first urban typology of ‘accelerating machine power’ is marked by the new technology hydraulic filling, the demand for green structures and good housing in the ever-expanding cities. The expansion plan made mandatory by the Housing Act of 1901 represents this development and brings about a new organization. The case of Blijdorp represents the development of three elements that are crucial to the Fine Dutch Tradition. The first is the scale enlargement in technology, the second in organization (ground politics) and the third is the aesthetics that go along with this.

Scale enlargement in technology in this urban typology is characterized by the lack of knowledge about the exact effects of soil mechanics, groundwater flows and foundation piles; drains are not used yet. A layer of sand can be applied but there are still ‘connectors’ to the original hydrological situation, like open water systems, in use. In Blijdorp this is the Statensingel, connected to the *singel* of the *Waterproject* and the water in the Zoo. The disconnection of the urban design from the physical geography, an important aspect of the Fine Dutch Tradition, has started. The series of designs for Blijdorp show this disappearance beautifully. The original landscape and its water system are no longer a structuring part of the design. Technology takes control over the unreliability of the territory and the urban design produces the desired urban form. Industrialization brings enlargement of scale on all layers: sand, roads, buildings, urban blocks and urban pattern. It is part of the great shift in urban construction and urban design where all layers slowly become based on separate fields of knowledge or domains and expertise, done by different professionals

The second aspect of scale enlargement is the organization. The municipality takes over the developers' role because of the scale. It is too difficult to organize private developers in an expansion plan, and there are priorities of common good: good housing and good infrastructure, both consequences of the industrial revolution. The urban block first followed the dimensions of the polder landscape and were built up by private developers, now the blocks are built on a 'clean slate' and are based on economics, production processes and ideas about good housing. The ability to produce large-scale urban plans, with the use of the new block type and large-scale integral filling of the area with sand, is refined; also by making a long series of plans for a considerable amount of time.

The last aspect is aesthetics that are no longer connected to the physical geography or the pragmatism that evolves in reaction to the natural system. Now more monumental designs are made based on function (public or private domain) and main transport routes. Somehow the rules and technology that enhance the possibilities of making an aesthetical urban plan take away the constituents of the making of Dutch towns, the Fine Dutch Tradition, and the cultural perspective brings about a more monumental plan with central axes and squares.

Chapter 5b: Accelerating Manpower (1945-1970)

Advanced Technology, Welfare State and Disintegration

This subchapter goes into the second urban typology in the Manipulative Phase from the Second World War until the 1970s. Key words of this post-war Phase are: advanced technology, welfare state and disintegration. Old religious, political and moral values and securities start to waver and the new paradigm of belief in a manmade culture – that relies on technology and systematic approaches – comes to maturity: *maakbaarheid*. This is applied to society in terms of social cohesion, social facilities, and control of the city and also of the water system and the attitude towards the natural system.[497]

During this Phase the spatial order of the Netherlands is fundamentally changed. The large projects of urban expansions, recreation, infrastructure and re-allotment of the agricultural pattern lead to a completely different appearance of the landscape.[498] In chapter five W.A. Segeren's statement that due to the method of building-site preparations urban designs do not have a relation to location is quoted. Specific conditions can be engineered and a tabula rasa is presented: urbanism ignores physical geography.

At the same time urban design is influenced by industrialization: standard housing and importance of infrastructure do not enhance the characteristic locality of the urban expansions either.[499] The result is a well-engineered layer of sand on which urban designs are realized. These designs are based on the principles of the international discourse of urbanism discussed at the CIAM. One example is the concept of the Neighbourhood City described in this chapter.[500] All over the Netherlands (and Europe) the neighbourhoods look alike; without locality, based on industrial technology and social structures that are very commonly has produced uniform cities.

Another characteristic of the post-war city expansions is the breaking up in networks like infrastructure, housing, recreation and nature. In the *Grachtengordel* and the *Waterproject* all these together orchestrate the city's ensemble. In the post-war city the main structuring element is (auto)mobility. The interweaving of networks becomes the skill of urban design but at the same time – professionally – these different networks are fields of knowledge of their own. Each part of a network has its own function and technology, which is not interchangeable, nor can it be integrated with another network. The water structure in this urban tissue has the function of recreation and otherwise becomes largely invisible in an artificial (underground) system of drains.

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[497] Cornelis 2000
[498] See for a complete overview on these matters Steenhuis and Hooimeijer 2009
[499] Segeren 1975, 11
[500] See Bos 1946

This second urban typology is comparable to Brown's drained city, one of the six distinct, cumulative transition states in the development of urban water management in Australia.[501] Brown's drained city is concerned with population growth and the development of drainage and flood protection. This is comparable to the Dutch situation, where urbanization causes 'sealing' of the urban areas and storm water needs to be transported away from urban areas as quickly as possible by combined sewer systems (for sewer and storm water discharge).

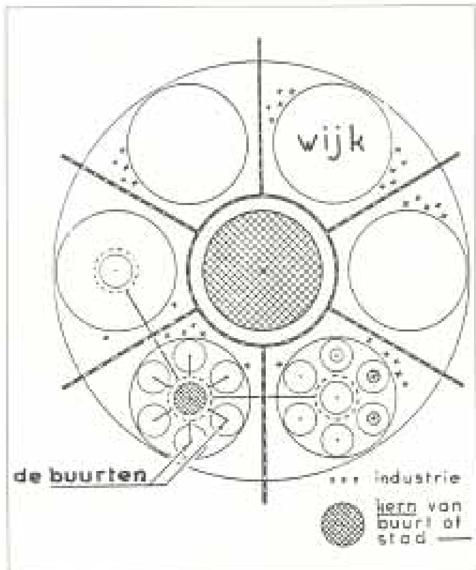
A feature of modern post-war urban design, besides the much maligned separation of function between housing, working, recreation and traffic, is the strict partition and distribution of projects among the increasingly disjointed disciplines of urban design, landscape architecture and civil engineering.[502] The neighbourhood city as product of the acceleration of manpower shows how the different disciplines (social, technical and urban) coincide in an urban typology.

This sub-chapter studies the Rotterdam cases Lage Land and Ommoord, both situated in the Prins Alexanderpolder and designed by municipal urban designer and CIAM member Lotte Stam-Beese. Lage Land is interesting for the plans that are made to present to the CIAM conference in 1953 and which connect the international concepts to extreme engineering. How it is finally built also represents its method of building-site preparation and never-ending urban pattern. Ommoord is interesting as a showcase for the thoughts of Stam-Beese on urban identity and her opinion about the engineering aspects of urban development when building in places with very inadequate soil conditions.

Neighbourhood City

After the Second World War the concept of the 'neighbourhood' becomes the steering force in the layout of city expansions. This concept comes from the American urban designer Clarence Perry, who wants to solve the social break up and densification of cities. Well defined neighbourhoods enhance the social coherence in cities that brings feelings of safety. The concept comes to the Netherlands through the Director of the Housing Commission ir. A. Bos. He chairs a state commission to study the needs of city dwellers during the Second World War. After the war the commission publishes the study *De stad der toekomst, de toekomst der stad* (The city of the future, the future of the city), which introduces the principle of the 'neighbourhood concept'.[503] It leads to a structural order, both physical and social. The only architect in the commission is W. van Tijen, who works out the concept in city designs.[504]

[501] Brown et al. 2008
[502] Van Eijk 2002; Calabrese 2004
[503] Bos 1946
[504] Damen 1993



Picture 5b.1 The neighbourhood city concept, showing the neighbourhoods, also subdivided in districts, around the city centre.
Source: Geyl 1947

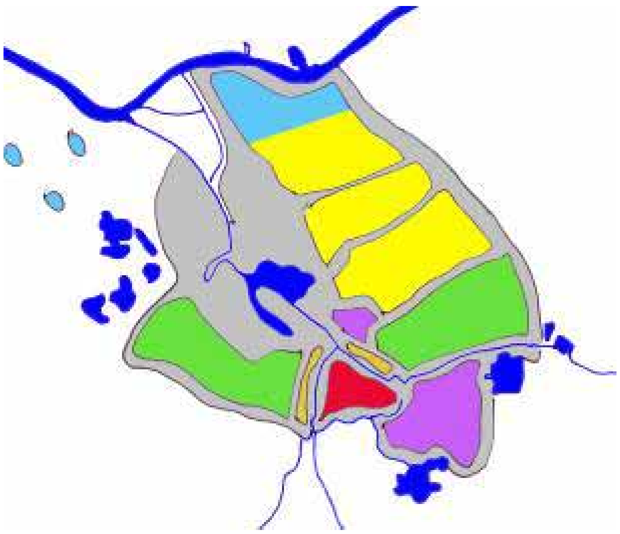
The scale of the post-war city expansions, divided into neighbourhoods separated by green structures, fits the technological progress, such as improved pumps and calculation methods, to prepare larger sites with a sand layer. This means that, in combination with an underground drainage system, significantly less surface water is needed. The civil engineer is responsible for improving the grounds and the urban designer can realize any city desired on this layer of sand. In the end the urban designer considers water as a waste product, to be situated on the outskirts of districts, integrated into the infrastructure or the green space system. The water systems as designed by civil engineers cannot be recognized as such, since underground pipelines alternate with the surface water. Whereas up to 1940 cities have a total surface of 12 to 15 per cent water, in post-war city expansions, this percentage is often reduced to less than 5 per cent.[505]

In the post-war expansions the scale enlargement in development (building-site preparation and industrial building) is complete. It perfectly suits the social tendency to believe that anything can be manmade: the city, the water system, social services and social cohesion. The latter is also explicitly an architectural ideal. The neighbourhood concept aims at a comprehensible structure of the city in smaller neighbourhoods with their own facilities, neatly ordered around the city centre. Like a babushka the city is made out of different skins and scales where sufficient facilities are provided. This survey-like approach has already started in the 1930s and is projected not only on quantitative urban artefacts, but also the qualitative ones. The different neighbourhoods are separated by green structures and the housing differentiated for different type of residents (senior citizens, families and young people).[506]

[505] Van Eijk 2002, 72-73
[506] See Bakema 1964, 1966

New Relation to Physical Geography

The neighbourhood concept is greatly promoted within the CIAM by Lotte Stam-Beese; she is member of De 8 & Opbouw and municipal urban designer in Rotterdam. For the conference in Aix-en-Provence in 1953 she and architect Jaap Bakema present plans for the expansion of Rotterdam in the drained lake Alexanderpolder: the Lage Land (more closely studied below). An interesting aspect of the plan is that it presents the vertical neighbourhood concept in which the method of building-site preparation (on piles) is crucial to preserve the original landscape. Stam-Beese also designed Ommoord (also studied more closely below), located north of the Lage Land and integrally filled in with a layer of sand.



Picture 5b.2 Den Bosch historic centre (red), early nineteenth century expansion (brown), expansion by Pieter Vehagen (purple), post war expansion (green), expansion in the 1970s and 1980s (yellow), expansion in the 1990s and after 2000 (blue). Each expansion has a lake for sand supply.
Source: Author

For that plan she claims that the loss of the physical geography brings about technical and uniform cities. However, the sand layer also produces a new physical geography: lakes that are created by excavating sand. The sand for the filling is usually harvested from a nearby lake; in the case of Ommoord and for example the Western Garden Cities in Amsterdam, a drained lake (respectively Zevenhuizerplas en Sloterplas). By taking the sand the (drained) lake becomes larger (or a lake again) and forms a spatial element of the neighbourhood as nature and recreation. In this manner in many Dutch cities' lakes are integral parts of urban expansions. Den Bosch is a very good example of this: every expansion literally has its own lake. The sand is usually transported by rail, which gives the lakes names like the Iron Man or the Iron Woman.[507]

[507] In the Netherlands many of lakes with the name Iron Man are still there: Eindhoven, Vught, Weert, the Iron Child in Hintham and the Iron Woman in Den Bosch. For more information about Den Bosch H+N+S landscape Architects and Vista 1999.

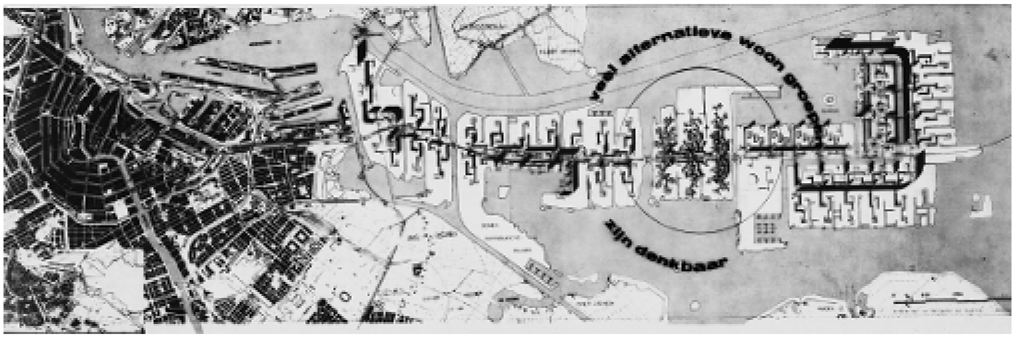
In the post-war era the relation of urban design to physical geography is generally not made; only a few examples in this period can be found. The work of Jaap Bakema and his office Van den Broek & Bakema shows that the landscape and water structure can be used to make the urban design.

Jacob Berend Bakema (1914-1981) worked with Cornelis van Eesteren for the urban development division of the Amsterdam Department of Public Works after graduating from the Amsterdam Academy of Architecture in 1941. Since Van Eesteren is very aware of the importance of water, Bakema must have realized this as well. The plan for Zestienhoven which the Van den Broek & (Jaap) Bakema office made in 1976 has an organically shaped urban layout that is structured by the polder pattern. This plan is more fully explained in chapter six. Van den Broek & Bakema also make a plan for Noord-Kennemerland (which is also not realized) that again shows the specific arrangement of ensembles with the water system.[508]

Picture 5b.3 Noord-Kennemerland by Van den Broek & Bakema 1957
Source: Architectengemeenschap Van den Broek en Bakema

Another famous water city by Van den Broek & Bakema is Pampus, in Amsterdam's IJ River. These plans are interesting in that they are the ultimate representation of the *maakbaarheid* principle; as well as total control of the polder. Pampus City is not realized; however is the conceptual mother of IJburg that is currently build in that area.

[508] See from more information Bakema biography by Ibeling 2000. Also his own publications Bakema 1964, 1966 and 1981



Picture 5b.4 Pampus City by Van den Broek & Bakema (1965)
Source: Netherlands Architecture Institute, Archive Van den Broek en Bakema (BROX)
Stedebouwkundige studies (PAMPUS)

Building-Site Preparation after the Second World War

After 1945 different forces are very influential in building-site preparation. The size of the building-site expands as the speed of building increases. Bad soil conditions slow down the building pace due to difficult access and therefore an economic loss and bad in times when the need for dwellings is high. The building industry accelerates and industrial processes, prefabricated construction in factories with assembly only at the building site, take over. This demands more from the accessibility of the site in load-bearing capacity and stability. The new expansions are situated on even worse conditions than the expansions before the Second World War, which are close to the city centres and have some load-bearing capacity and drainage possibilities. Urban designers have less time to prepare their designs and planning for building-site preparation is therefore done separately, at the same time. The demands for the quality of dwellings and public facilities like the surroundings, water management, cables and tubes become higher, and so do the total costs of building-site preparation. [509]

The period of building-site preparation until 1984 is evaluated by the Department of Public Works in Rotterdam: *Methoden van bouw- en woonrijpmaken in Rotterdam* (Methods of building-site preparation in Rotterdam). This report is quite useful to show which methods of building-site preparation are applied in Rotterdam. It is extensively used in the following paragraphs to describe the different methods.

From the 1960s on, the accent in Rotterdam is on integral filling with a layer of sand with vertical drainage to accelerate land subsidence. Until the mid-1960s, Rotterdam uses the traditional method of sand strips under streets and parking lots: the ‘cunet’ method. The building sites are filled in by the construction company or the developer. Sites where subsidence occurs very easily (like the neighbourhoods Keizershof and Hoogerbrugge in Ommoord) are prepared using this method. Only low-rise buildings are built there. The negative points of the cunet method are 1) the preparation is fragmented, 2) the urban plan needs to be fixed, 4) dwellings are more expensive due to the partial filling, 5) over all subsidence, and 6) subsidence

[509] Gemeentewerken Rotterdam 1984, 12

differences between the street and the houses can break the sewer connections and cause bad draining conditions in the green areas due to differences in height.[510]

Vertical drainage significantly reduces the duration of the subsidence process. In a 3 x 3 m grid, holes with a 30 cm diameter are drilled in the clay or peat and filled with drainage sand. The water drains more quickly and consolidation will be reached sooner. The green areas are filled in traditionally with 50 cm of black soil. This method is applied for the first time in Lage Land (Rotterdam) in the 1960s. The positive aspect of the cunet method is that the subsidence is only 15 cm and keeps down maintenance costs.[511]

The most commonly used method of building-site preparation after the Second World War is hydraulic filling, using water to spread the sand over a large area (a spout section can be 15 ha). The water that transported the sand (return water) is then discharged by a pipe. The green areas need to be constructed by the partial removal of the sand and the addition of black soil. This method is used in the post-war expansions in Amsterdam (Western Garden Cities) and in Rotterdam – the first time in the Land of Hoboken and the second in Blijdorp. The whole process of building-site preparation is more regular because the whole area is prepared at once. There is less dependence on the urban plan and changes can be made easily. Building sites have the same load-bearing and drainage capacity as the road strips in the cunet method. Private gardens and public green areas also suffer from subsidence. Because a large amount of sand is needed it has a positive effect on the price of the sand. This method does mean a higher investment because the site needs to be available early and a large amount of sand is required. Some projects, however, face a residual subsidence of 50 cm, which means maintenance costs for the stabilization of roads, pipes, sewer and cables. Also, the connection to the houses can be damaged due to the subsidence. The most negative effect of hydraulic filling is the fact that the original landscape cannot be the base for green structures. It is completely wiped away. Black soil needs to be added for fertile site for public green space and private gardens.[512]

Adding vertical drainage to hydraulically filled areas reduces subsidence and even more so maintenance costs after completion. The process is not fragmented and the urban plan can be changed without high costs. Building sites (private and public) and streets are of equal quality, with the same subsidence, and for a lower sand price due to the large amount purchased. Negative aspects are the higher investments, the large amount of sand required, the loss of the original landscape and the necessity to add black soil for the green structures.[513]

For small-scale development the method of filling with sand transported by truck and with vertical drains is very useful. It is applied for the first time in Ommoord. It is a slightly different method than that described above and has the same positive and negative effects. An additional positive aspect is that a partial purchase of the site is possible. A negative aspect is the

[510] Gemeentewerken Rotterdam 1984, 15
[511] Gemeentewerken Rotterdam 1984, 16
[512] Gemeentewerken Rotterdam 1984, 17
[513] Gemeentewerken Rotterdam 1984, 18

additional cost due to the transport of sand by road.[514]

Another method is to apply a first layer of sand transported by truck, topped by a second layer applied hydraulically, with vertical drainage. This method is used in areas where soil conditions are extremely bad and simply applying a layer of sand will result in imbalances of the site. The first layer of sand that is transported by truck balances out the soil conditions, improving them to the point where the second layer can be added hydraulically. This method is never used in Rotterdam at that time, but it is studied in Prinsenland, which has poor soil conditions and a lot of existing buildings in the plan area.[515]

In the 1960s the Rotterdam Department of Public Works develops the vertical sand pile to speed up the subsidence process of the layer of sand, the main subsidence will then occur in the first two years. This becomes very successful and is for the first time fully applied in Zevenkamp, the case in the next chapter.

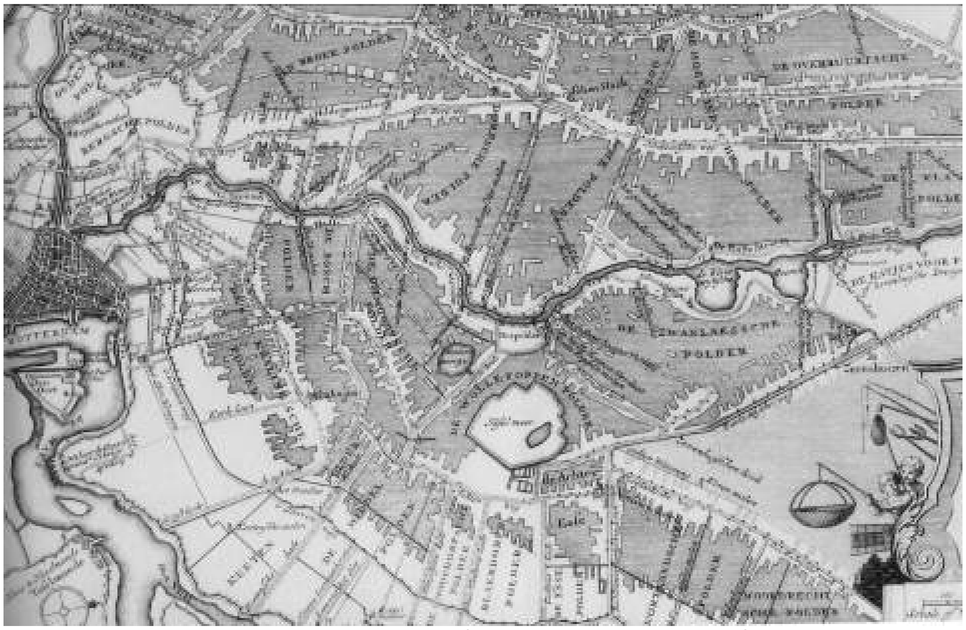
Besides vertical drainage, horizontal drainage is applied in urban areas to accelerate groundwater flows and have better control over the groundwater level. Horizontal drains made of earthenware pipes (originating from the agricultural sector) are applied to speed up subsidence and thus stabilize the soil. They are also used to lower the groundwater level to reach the desired freeboard.

Rotterdam Prins Alexanderpolder

Land and Water, Water and Land

Until the Middle Ages the area is a part of the large peat swamps of Middle-Holland where the dynamics of sea and rivers have free rein. A small dike is probably built in the ninth century along what is now the ’s Gravenweg, but the reclamations start in the tenth century with the use of the ‘cope’ system (fan-shaped pattern of lots that came about by the way it is reclaimed) with the Rotte River as primary reclamation basis. The area becomes flood free when the small dike on the line of ’s Gravenweg and Oudedijk is reinforced around 1170. Slowly the extraction of peat starts in a small-scale fashion. From 1530 to the eighteenth century the extraction of peat becomes a large-scale activity leaving a landscape of large lakes, islands and dike ribbons. The west side borders the Ommoordsekade (dike), the current Terbregseweg, the north side the Rotte and a strip of ‘bovenland’ (high land) at the east side by the Rijskade, the current Schout Bonten-balpad and Capelseweg.[516]

[514] Gemeentewerken Rotterdam 1984, 18-19
[515] Gemeentewerken Rotterdam 1984, 19
[516] Palmboom 1993, 30

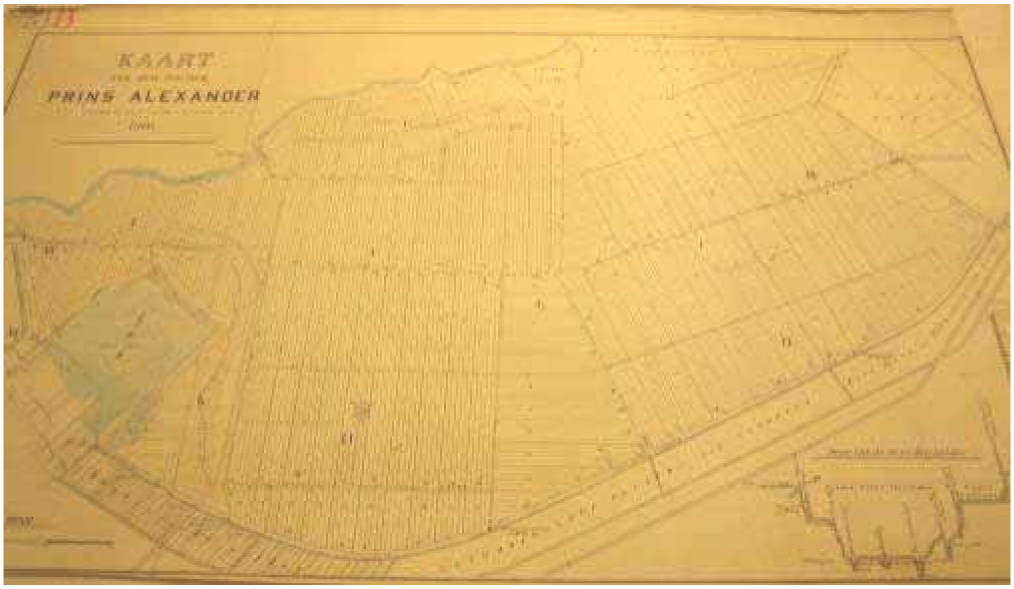


Picture 5b.5 The reclaimed peat polders are filled with water because of the peat harvesting (1750).
Source: Municipal Archive Rotterdam

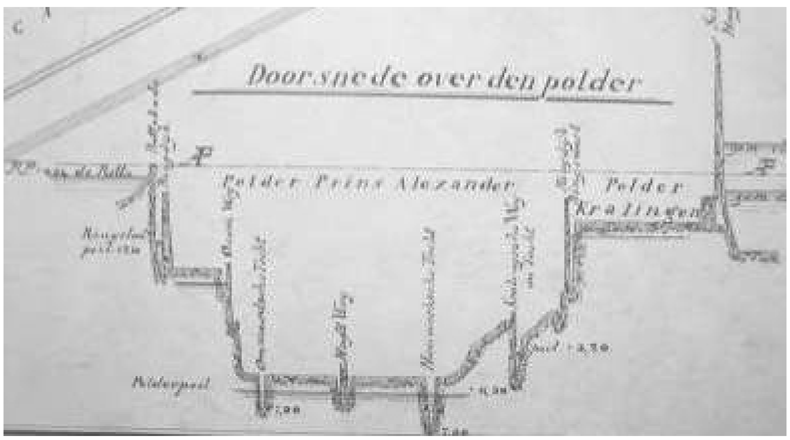
In 1862 the Province of South Holland and the national government decide to drain the lakes. An encircling outlet water way (*boezem*) with dike is built and the water is pumped out by three steam pumping stations at Kralingen, Capelle and Nieuwerkerk. The steam pumping station at Kralingse Veer pumps the water into the New Maas. Pumping starts in 1869 and in 1873 the whole polder of 2,668 hectares is dry, a year later all the lots are sold mostly to horticulture farmers.

Not all the lakes are pumped dry, the Northern Lake, now known as the Kralingse Plas is kept as a lake for recreation (that is sailing and walking in those days). The *boezem* is built partly along the Rotte. All the remaining dikes (*kades*) are removed but the islands in the northern part remain as bumps in the new landscape. Because of the low situation of the areas (NAP - 3.5 to - 5 m) and the peat an intensive drainage system is necessary. Small-scale strip parcelling, orientation north/north-west and north-east/south-west appear. Perpendicular to this the Sluipwijkse Tocht (draining ditch) and Ommoordse Tocht are built. Around 1900 the Ommoordseweg and the Hoofdweg (main road) to Gouda are positioned. Along these canals, roads and the Rotte River, the cattle farmers in the area build their farms. These form the characteristics of the landscape from which – even though a lot of effort is taken to keep it dry – peat is still excavated well into the 1930s.[517]

[517] Palmboom 1993, 31



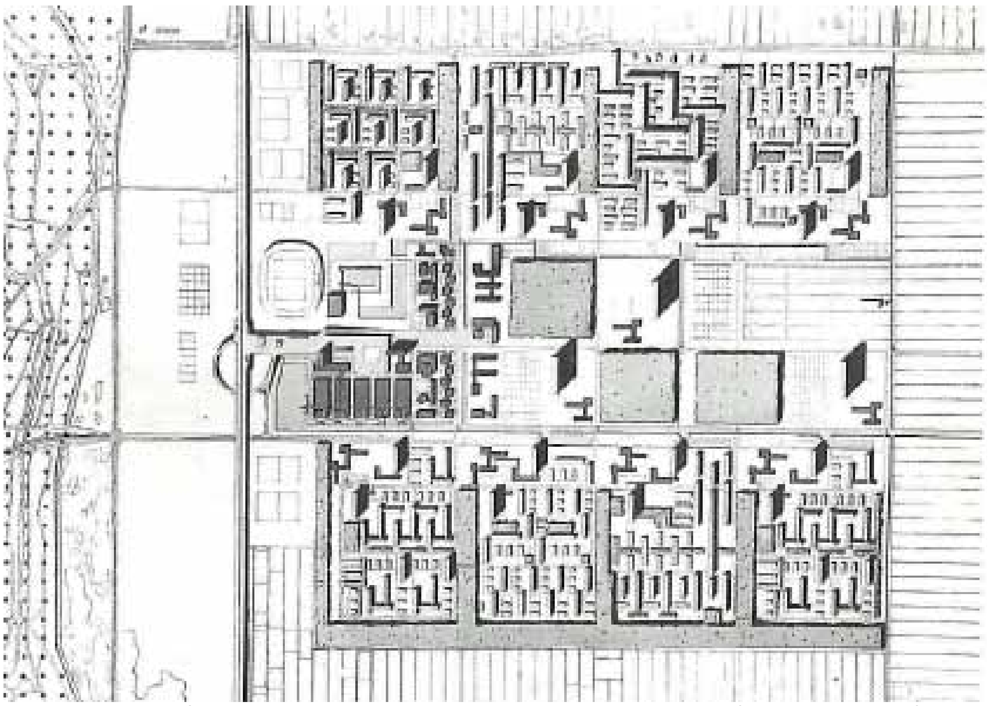
Picture 5b.6 Land: plan for Alexanderpolder 1915
Source: Municipal Archives Rotterdam, 2609, 4F, 1915



Picture 5b.7 Section of the Alexanderpolder
Source: Municipal Archives Rotterdam, 2609, 4F, 1915

Urbanization Dynamics

After these many radical metamorphoses from water to land to water and back to land again, the era of urbanization of this very wet and weak subsurface polder commences. The driving force behind these changes is the vacillating relationship between city and countryside: Alexanderpolder's function develops from farmland to fuel reservoir, to horticulture to urban expansion and recreational area. The dynamics play out on different levels, the reclamation and the impoldering are large-scale operations, the extraction of peat on the scale of the lot, but they have the same impact. The first urbanization reflects the landscape structure with the filling in of urban functions (factories, villa parks, and building blocks) lot by lot following the polder pattern. Fragmented zones in the pattern, however, lead directly to discontinuities in the network of streets resulting in a lack of coherence between the parts of town in some places. Not until the Housing Act of 1901 is there an instrument with which the urban layout can be controlled. Previously attempts to define and connect the city with infrastructural lines failed; only when the polder pattern is covered by a layer of sand it is possible to design a city based on infrastructure.[518]



Picture 5b.8 Plan for Lage Land that Bakema and Stam-Beese designed for the CIAM conference
Source: Palmboom 1993

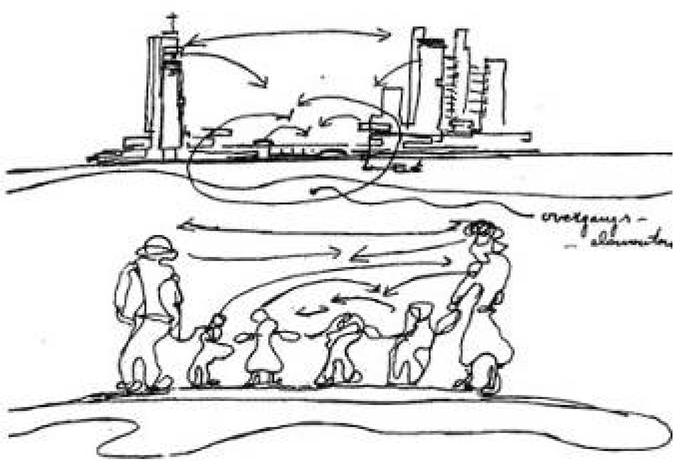
In the Basis Plan of 1946, drawn up by the Director of the City Development Office Cornelis van Traa, the Alexanderpolder is designated as expansion area. A total of 700,000 houses is planned in satellite cities to the east and west of the city, those being the only possible directions of expansion. The first ideas for the large-scale urbanization of the Alexanderpolder come not from the municipality, but from 'Opbouw', a group of architects started by Willem Kromhout and Martin Brinkman (1920) connected to the CIAM. Two member of the group, Lotte Stam-Beese and Jaap Bakema, present their plans the Lage Land, at the CIAM conference in Aix-en-Provence in 1953.[519] They choose this site in collaboration with Van Traa, because a huge challenge is presented to design a sub-city in these low-lying polders for the ever-growing number of residents of Rotterdam. Rotterdam cannot expand to the north and because the city centre is moving to the west they consider an eastern expansion, even in the deep wet polders, as the best contra balance. The expansion needs to be independent of the city and flexible concerning unpredictable growth numbers and economic developments. It must also be spatially flexible and able to grow fast or gradually, depending on what is needed. And of course the geographical circumstances have to be

[518] Palmboom 1993, 34
[519] The conference is actually not about the urban scale, but about the meaning of the dwelling and the way it is lived in: Habitat

taken into account. In 1955 the plans are presented in a huge model as 'the city of tomorrow' at the exhibition E-55 in Rotterdam.[520]

To this Rotterdam context Stam-Beese en Bakema connect the 'visual unit' (a concept by Bakema) and the 'neighbourhood concept' (*wijkgedachte*). The neighbourhood concept, as described above, is a construction on a flat surface: the city map. The 'visual units' make this a three dimensional composition by introducing a sort of vast elementary sculpture in which architecture and urban design converge. In the course of Bakema's work the visual units take on an increasingly larger scale, culminating in his Pampus Plan of 1965.

In the plan for Alexanderpolder the 'visual units' are directly linked to the highway and function as autonomous urban units. The geographical circumstances of the deep lying polder and the poor soil conditions are the reason for Opbouw to introduce the idea of these vertical neighbourhoods.[521] The method of building site preparation that connects easily to this concept is 'living platform'. This means that the foundation piles (necessary for stabilization of the buildings) are used the have the buildings "float" above the surface. The highway and these 'Mammoths', as Bakema calls them, float above the polder landscape that remains in use for agriculture or recreation.[522]



Picture 5b.9 Sketch by Bakema showing the' visual unit' principle, 1961
Source: Bakema

[520] Damen 1993, 69
[521] Schild 1982, 139-170
[522] Palmboom 1993, 38

Picture 5b.10 Bakema's 'Mammoth', attached to infrastructure, raised on (foundation) piles above the landscape.
Source: Palmboom 1993

In this respect this plan is reminiscent of New Babylon by Constant Nieuwenhuys (1920-2005), known as Constant. New Babylon is a Utopian anti-capitalist city in a post-revolutionary society that Constant designs in 1950. Here the "playing" human, *homo ludens*, can have alternative life experiences. The city is a transformable structure - a mega structure - that has smaller units, some of which themselves are the size of a small city. Perched above the ground, Constant's megastructures will literally leave the bourgeois metropolis below and is populated by homo ludens. [523] Under the megastructures the landscape is kept intact.

In the 'Samenvatting van overwegingen bij nadere doorwerking van het plan' (Summary of thoughts considering the development of the plan)[524] Stam-Beese describes the different steps in the planning process and arguments used for these steps. All the sketches take the polder structure as a basis and the highway is also a given element. Different compositions are made up, with different configurations and numbers of the element's 'core' (the sub-city), the Mammoths and housing. Each dwelling type (family house, apartment building and high-rise Mammoth) has a typical allotment unit, a defined character and a relation to the surroundings. The family houses are connected to a private garden, the apartment buildings to a common garden and the Mammoths to public space and the existing agricultural surroundings. In the Mammoths, which free the ground from private use, only open minded people can live because they can connect to the open landscape acoording to Bakema.

In the final plan of 1953 (discussed in the next paragraph) there are two residential zones (consisting of two districts of 4,000 people each) with a green belt in the middle that accommodates the core and three Mammoths (for 350 families each). The dimensions (scale and positioning of the blocks)

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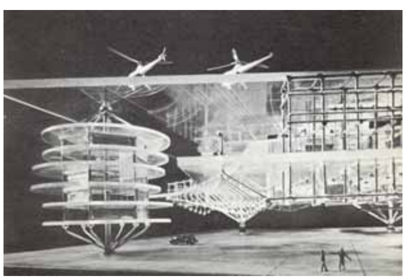
[523] See for the biography Wigley 1998
[524] Rapport van Lotte Stam Beese en Hovens Greve van 10-6-1953 in het Archief van Stam Beese in het NAi.

of the new expansion are directly connected to the scale and dimensions of the surrounding landscape, the agricultural allotment, suggesting that the city can grow over the countryside in this pattern endlessly.[525]

Picture 5b.11 Constant's New Babylon Paris, 1963. The megastructures projected over the city.
Source: Haags Gemeentemuseum



Picture 5b.12 Constant's New Babylon, model of a mega structure
Source: Wigley 1998

[525] Palmboom 1993, 38

Rotterdam Lage land

Part of Alexanderpolder is the district called Lage Land, meaning 'low land'. It is one of the lowest areas in the Netherlands. It is surrounded by heavy infrastructure. Between 1950 and 1953 the railway between Rotterdam and Gouda, the Rijnspoorlijn, is moved to the north of Rotterdam, boardering north of Lage Land. In 1963 a highway is also built in the same line 100 m to the north. The road is stabilized on a large sand slope that lifted up the highway significantly in relation to the deep-lying polder. It is interesting that in this period of time the nineteenth century ideal of the concentric city, defined by a distinct border, is still popular. Development plans still aim at limiting the growth of the city by defining its external boundaries and at dividing the city into units on a restricted and comprehensible scale. The large-scale infrastructural lines are used as 'natural boundaries'.[526]

In between these 'new' borders the municipality starts planning Lage Land in 1959. Basis of the design is laid in the expansion plan 'Prins Alexanderpolder', approved in 1957. After L. de Waard makes some designs, Lotte Stam-Beese takes over in April 1961 to develop the eastern part of the area.[527]

Lowering the Groundwater

In 1956 the first ideas about expanding the city in eastern direction are published and the first opponents of the plans express their complaints. The community of Kralingen understands the need for the expansion but is disappointed that Kralingen will no longer be on the outskirts of the city, close to the countryside. The loss of agricultural ground is also regretted. They ask for recreational areas in the new expansions to keep the Kralingen Lake from being overcrowded and they plead for a spacious layout of the new district, they miss places for children to play in Kralingen.[528]

In the Alexanderpolder many different landowners also express their complaints, in total 409 complaints reach the municipality: 73 private owners, 97 agricultural businesses, 141 horticulture businesses and another 98.[529] The Schieland Water Board also considers the plans insufficient and at that point too vague to make any judgement about the possible consequences for the water system. They take the position that until the plans are more detailed they are against it. They oppose the use of harbour silt (a method used commonly in Rotterdam) for filling the area, because that silt has a high salt percentage, which will salinate polder water.[530]

The polder boards of Kralingen and Prins Alexander are also critical of the plans. The sacrifice of agricultural grounds and the change of the water system are both difficult in their eyes. Different areas will be cut off from the pumping stations, and the highway will also alter the system drastically

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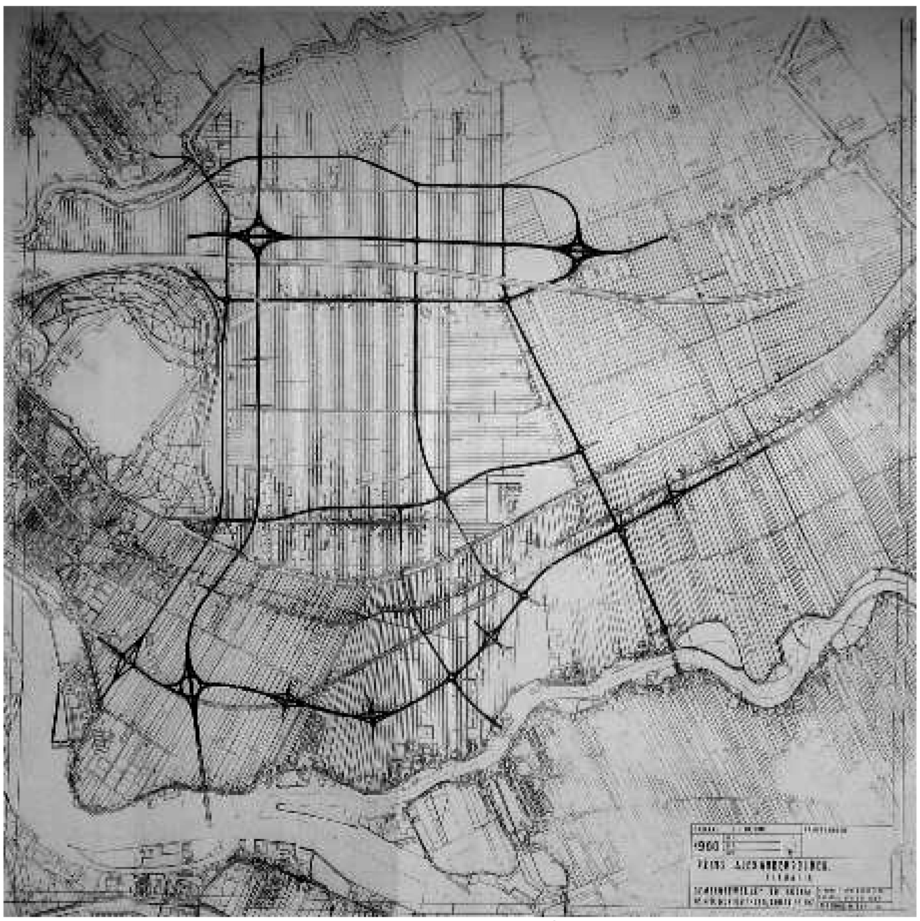
[526] Palmboom 1993, 35
[527] Zweerink 2004, 215
[528] GAR secr. Afd. Openbare werken 465, 175 uitbreidingsplan prins Alexander, Brief wijkraad voor Kralingen 10 juli 1956
[529] GAR Bezwaarschriften secr. Afd. Openbare werken 465, 175 uitbreidingsplan prins Alexander
[530] GAR secr. Afd. Openbare werken 465, 175 uitbreidingsplan prins Alexander, Hoogheemraadschap van Schieland 6 november 1956

and cause problems for the neighbouring areas. They are also opposed to hydraulic filling of the area because the return water cannot be discharged through the polder system. Filling in the area will also cause seepage in the lower-lying surroundings. These are reasons enough for a more detailed plan to ensure that the water system and management, and also the sewer system, will be worked out properly. The polder board of Prins Alexander suggests that the area will have to be heightened with 10 m of harbour mud, taking into consideration that the level is -6 m MSL and that subsidence will occur. They also point out that the salination will make exploitation of the surrounding grounds difficult and will change the water system and the soil build up (the first 8 m is peat, with 6 to 7 m of weak clay and sand underneath). Raising the ground will also create a sideways pressure on the levees (*spuitkades*) that has to be worked out.[531]



Picture 5b.13 Situation in 1960 with the projection of new roads in Prins Alexanderpolder
Source: Archive Public Works Rotterdam, 207-4

The municipality responds to all complaints that they will keep the specified aspects in mind when developing the area. The polder board of Prins Alexander replies that the municipality has to discuss their plans at an earlier stage (and before taking the plans to the public), because the water

[531] GAR secr. Afd. Openbare werken 465, 175 uitbreidingsplan prins Alexander, Polder prins Alexander 5 november 1956

management aspects are crucial in making the plan.[532]

On 21 October 1957, the municipality of Rotterdam receives permission from the Prins Alexanderpolder to expand the city in their polder, with some water system restrictions. Instead of filling in the area they have to lower the groundwater table from 6.80 - to 7 m -MSL, make 13 sewer overflows on the level 6.80 m -MSL, and dig a drainage canal around the area. The polder ditches can be closed if a new canal is made to replace their capacity. The new canal is 2,100 m long, 6 m wide and 1.5 m deep.[533]

Next to the lowering of the groundwater table, the area is prepared with 'cunet' fillings: sand strips under roads, transported by truck, with vertical drainage that speeds up the subsidence process significantly. This method is applied for the first time in Lage Land. In a grid of 3 x 3 m, holes with a diameter of 30 cm are drilled in clay and peat and filled with drainage sand. The water is drained quicker and consolidation will be reached sooner. The green areas are topped with 50 cm of black soil. The positive aspect of this method is that the residual subsidence (the subsidence after constructing the houses and roads) is only 15 cm and keeps down maintenance costs. The negative effects are:

- The fragmented preparation;
- A fixed urban plan;
- Due to the large amount of sand, a high pre-investment;
- Bad quality of building sites in adjacent areas due to the overflow of drained water;
- Risk of break in sewer because the houses and the streets are separated by filled gardens;
- Difference in subsidence between green and built areas;
- Bad drainage in green areas.[534]

Urban Plan

The fact that the area is not integrally filled in with a layer of sand but that the method used will preserve the orthogonal structure is perhaps the reason for Stam-Beese to use the polder allotment as an infrastructure system. In the CIAM plan the former agrarian polder pattern is also kept as a quality and, of course, a form that never ends. The main streets are constructed using the 'cunet' method at the end of the 1950s: Prinsenlaan, Berlagestraat, Koningslaan, Jacob van Campen-weg and the Hendrik Staetsweg. These streets are based on the orientation of the former polder pattern. The intermediate streets, *singels* and buildings are not always positioned in this grid. Between 1958 and 1970, apartment buildings and ground-bound family houses are built in the area. Under the houses there is a layer of sand and the gardens are filled with black soil. Between 1970 and 1975 in the area south of the Prinsenlaan large-scale apartment buildings are built.

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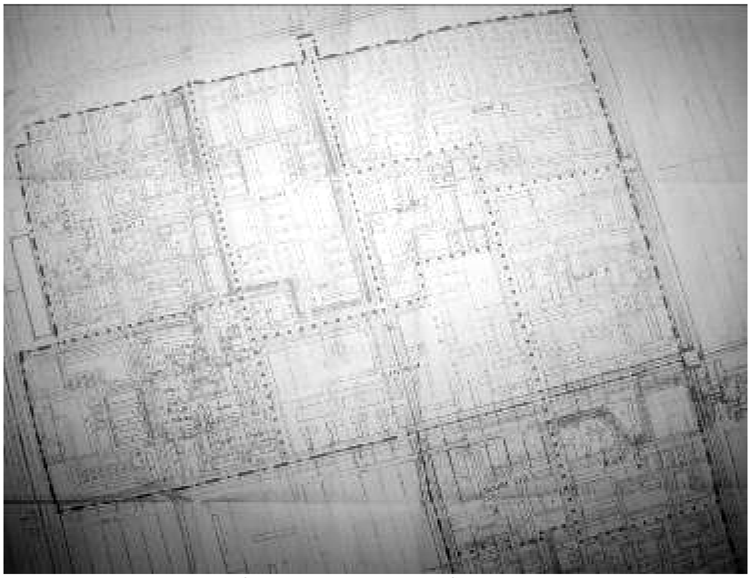
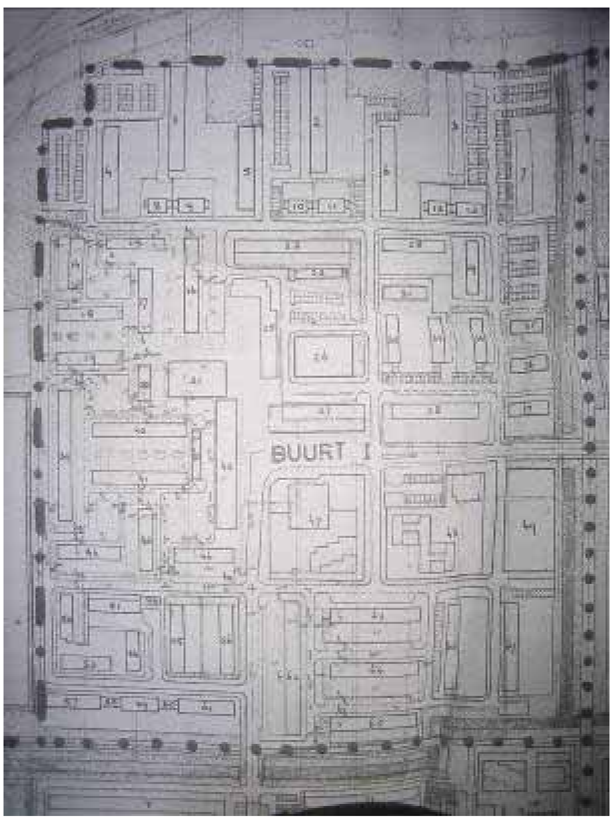
[532] GAR secr. Afd. Openbare werken 465, 175 uitbreidingsplan prins Alexander, Brief polder prins Alexander 23 april 1957

[533] GAR secr. Afd. Openbare werken 465 465.01 – 634 bemaling pr Alexander, brief polder

[534] Gemeentewerken Rotterdam 1984, 16



Picture 5b.14 Drawing for the realization of Lage Land.
Source: GAR secr. Afd. Openbare werken 465 179 lage land, Plan Rotterdam Oost, het Lage Land, Globale exploitatieberekening 28 okt 1963



Picture 5b.15 Individual builders decide whether or not to raise their sites. In District 1: block 65 (four apartment buildings), block 63 (three apartment buildings), block 64 (eight apartment buildings), block 38 (a seven-floor high-rise) and block 63 (three floors) are built on raised land, the others are not. Almost all of the buildings in districts 3 and 6 are high-rises and both areas are raised. The plan is quite expensive because of this.
Source: GAR secr. Afd. Openbare werken 465 179 lage land, Plan Rotterdam Oost, het Lage Land, Globale exploitatieberekening 28 okt 1963

The exploitation of the area shows that the costs of filling parts of the public areas are paid by the municipality, a total of 392,940 m^2. Houses are built on filled in sites at the developers' cost; consequently not all houses are built on raised ground see picture 5b.15.

Picture 5b.16 Lage Land with the Kralingse Lake behind it.
Source: Palmboom 1993

Lage Land in 2011

The post-war neighbourhoods receive a lot of attention because of they do not meet what are now considered acceptable living standards. The houses are too small, have no central heating and old kitchens and bathrooms; the public space is too anonymous to function well and is often inadequately maintained. Therefore today this is a large sociospatial challenge and throughout the Netherlands these neighbourhoods are being restructured. Sometimes large-scale demolition and complete rebuilding of areas is done; densification is also applied to solve the problems in these areas. Smaller houses are sometimes combined to form fewer but larger apartments in buildings; the large green structures (sometimes called snooker greens) are given more specific functions, divided into private gardens or built on with ground bound houses. The reconstruction of post-war areas is quite a large operation within the spatial order of the Netherlands.[535]

This is also the case in Lage Land. In September 2001 the sub-municipality of Prins Alexander approved a neighbourhood vision *Het Lage Land*. The vision aims at renewal of the area by adding new houses, breaking down houses and replacing them with new ones and the renovation of houses (modernize and enlarge by merging). The reconstruction of public green is also on the agenda.

The water issues in the Lage Land mentioned in the Waterplan 2 refer only to quality not quantity. However, the sub-municipality of Prins Alexander is setting up a *Waterplan* and one of the aims is to address the water nuisance in Kromhoutpark. Since the Lage Land is a very deep polder dependent on pumping, severe rainstorms do cause problems in certain places. The water nuisance in Kromhoutpark is solved by building a 'vegetated infiltration swale (*wadi*)'. This swale catches the water, which can then slowly evaporate or infiltrate and be pumped out over a longer period of time.

In the context of the international discourse on urbanization, the Lage Land is not only an interesting example itself, but also an example of a development in the particular context of being situated in a deep and wet polder. The internationally renowned ideas of Bakema and Stam-Beese are, in applied form, realized in the Lage Land in the connection to the agricultural landscape and the use of megastructures, the mill shaped apartment buildings. The Lage Land is characterized by the ideas of the CIAM and the locality of place.

The use of structures and constructions has become a condition to urbanize the polder. In the first instance the polder is pumped to enable agriculture, for urbanization the pumping capacity is enlarged to make the groundwater table even lower and the freeboard higher. This results in increased dependency and also of trust in the force of the pumping station. In the urban design (maybe even implicitly) the landscape allotment as the expression of the dimensions of the water system is a primary condition. The method used to prepare the site, groundwater lowering in combination with cunet, supports this relationship between the urban design and the water system. The fact that the enlargement of the freeboard stimulates subsidence on the longer term is taken for granted in Rotterdam.

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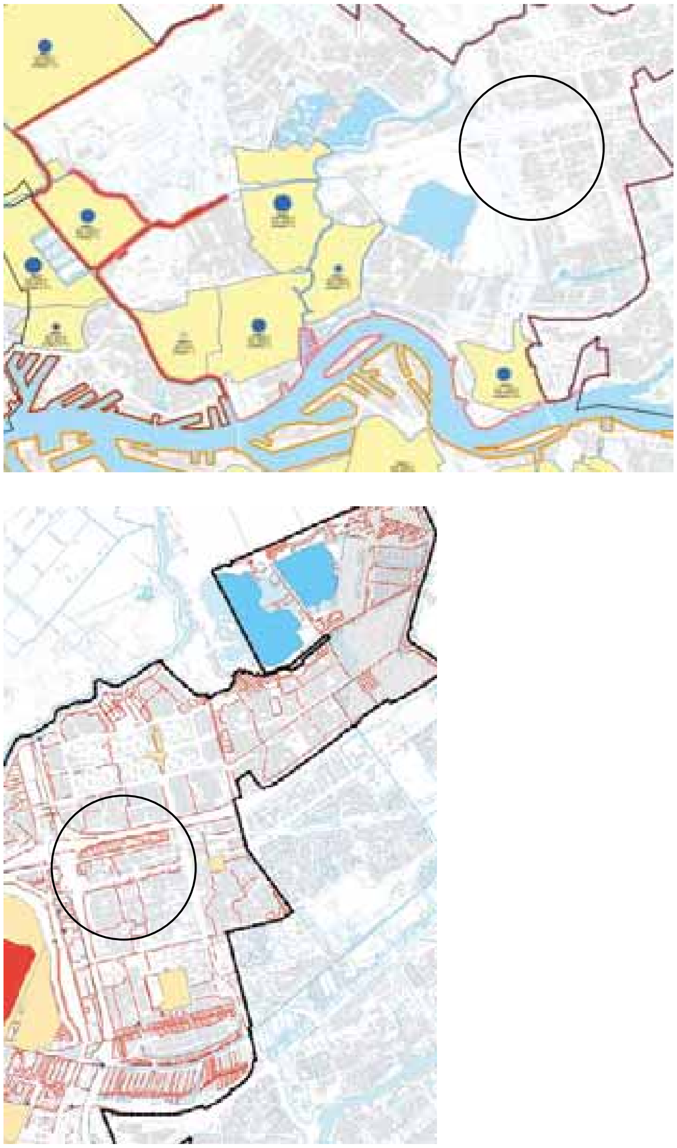
[535] This reconstruction of post-war areas is quite a large operation within the spatial order of the Netherlands.Van Eijk (2002) makes the connection to the water issue beautifully. Other publications Zweerink 2004, Bosman 1995, Helleman et al 2001,



Picture 5b.17 In Lage land there is no quantity issue but there is a quality issue with the water system.
Source: Waterplan 2

Rotterdam Ommoord

In the 1950s and 1960s Ommoord is a focus of international interest within the world of architecture and urban design. The residential areas have to be situated as conveniently as possible to the areas where the people work. The layout is quite spacious and contains a large area for recreation. Great attention is paid to the provision of variation in typology to ensure a difference in residents.[536]

In 1963 the 'Stuwgroep Ommoord' (Ommoord committee) is set up to ensure the architectonic and urban quality of the area. The group works on:

- Phasing of realization by purchase of land;
- Coordinating building-site preparation and the temporary road construction;
- Defining the desired variation in typology, size and rental or privately owned housing;
- Stimulating efficiency by coordination of teams of developers, architects and constructors;
- Preparing general plans and plans for special facilities to create a harmonious building process on the fundaments of modern urban design.

The aim of the committee shows a soaring ambition to connect with international developments.[537] The area is to contain 10,000 houses in 1965. The design for Ommoord is made by Lotte Stam-Beese as part of the RoCa (Rotterdam-Capelle aan den IJssel) Structural Plan of 1967, but a series of studies precedes this design. As early as 1962 Stam-Beese draws a plan with a an orthogonal grid of roads (not according the polder pattern as in Lage Land) and the usual division of family houses, apartment buildings and high rise flats. Again she uses the flats positioned in a mill wing ensemble to accentuate the border.[538]

Later the programme of the area alters and different sketches are made with more family houses and consequently more high-rise flats; the apartment buildings are especially subject to criticism. Stam-Beese groups the high-rises in the middle of the area and the family houses around them, in districts divided by green strips. The subway line is situated through the park and around the two stops she plans shopping facilities.

In the final design in the RoCa, a strict division of high-rises and low buildings is employed. The situation of the subway line and facilities and the separation of different low-rise districts by green strips also remain in the final plan.[539] The height differences in the park (the old bumps) are used and enlarged with sand to make a 'natural' landscape design. This design is to take the rough edges off the original stiff and monotonous character of the polder landscape.

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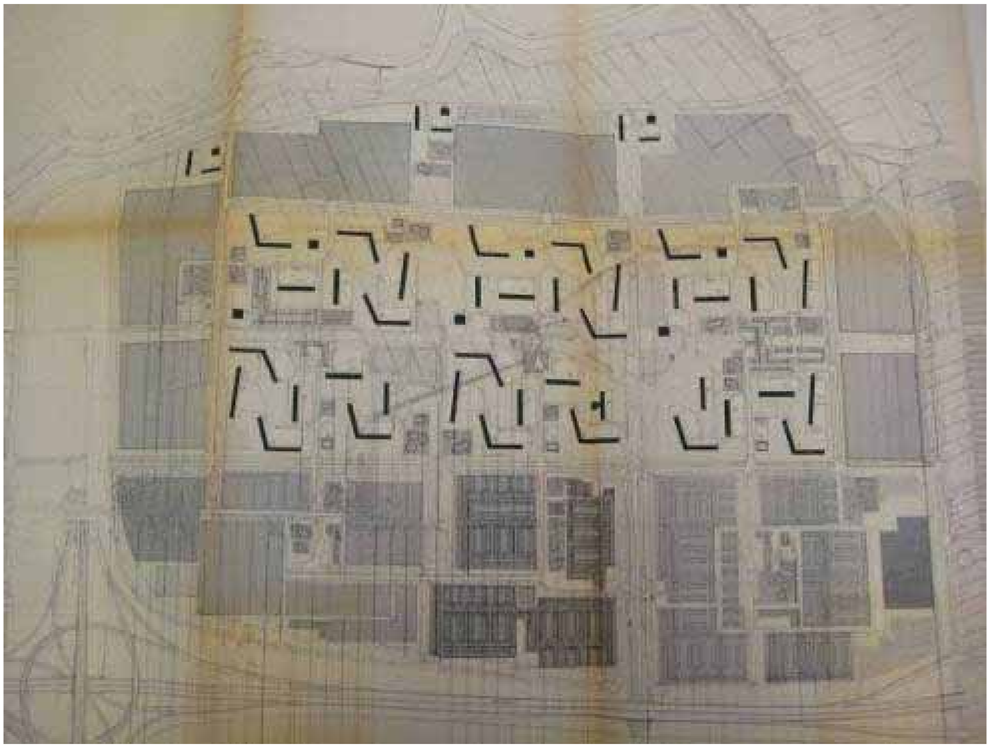
[536] Handelingen der Gemeenteraad, 27 mei 1946, pp. 129-181
[537] Verzameling der Gedrukte Stukken, volgnummer 370, 11 december 1963.
[538] Damen and Devolder 1993, 85
[539] Damen and Devolder 1993, 87



Picture 5b.18 Plan Ommoord
Source: NAi archives Lotte Stam Beese no 121

Characteristic Environment

After the Lage Land Stam-Beese designs the expansion plan Ommoord. She writes about the effect that the integral filling of the polder with sand has on the urban design:

> The failure starts with the choice of the location for the new residential area. We have no good choice for a proper place. . . . The result is that due to the need for houses the residential areas come about with a rational-theoretical model, just like the Roman army camps, and miss the natural geographic that used to characterise former settlements: the valley, the river crossing or mouth, the presence of water or the safety of a mountain tip. The presence of the geographical characteristics and the internal coherence with them produced the urban design; it gave these settlements and their resident's identity. Therefore it is not surprising that the current city expansions show great resemblance with the Roman army camps in lack of morphology. These camps also had no structural connection to their geographical situation, are independent and characterised by a singular function. Ommoord is built on the worst soil conditions possible. To be able to build there the whole area has to be drained with sand piles. This is not only very expensive but also restrictive in the detailing of the urban plan. For example a walking way on sandy soil in Drenthe can be made just by the people walking there, but here the walking way needs to 'be made' with improved soil. The brick fence of playing areas needs a pile foundation in these conditions

> and is therefore too expensive. All these simple impossibilities produce an urban plan without an inOffensive character and become emphatically wanted and technically efficient. Added to this is the fact that technology always strives to perfection. But are we happy with ultimate perfection, with efficiency beyond efficiency? Why do children prefer to play in the mud and in messy places and do adults like to go to campsites and organise pick nicks?
> The only positive side of the location of Ommoord is the river Rotte and the Rotte lakes. These are going to be expanded end better enclosed according to the recreation plan 'Rotte-meren'. This condition means some meaning of place to the new residence and a more plural functioning of the area. Already from the high flats the view on the landscape is stunning. The lack of a natural geographical environment, like described above, is visible in many new expansions: houses and flats are arbitrary lined up without taking the residents into a characteristic environment. . . . Why all the fuss, the disgust and dissatisfaction that is expressed in the media? The answer can only be that there is a consciousness about the lack of a residential environment for residents to feel at home. Everybody needs a home.[540]

Again, the term 'efficiency' is raised and Stam-Beese refers to it in the same way as Webber and Rittel do; as making all means work in the best way to the highest reachable end, with a military discipline. However, she has to work in the reality and for the design of Ommoord she tries to conceptualize a *characteristic environment* designed with a green heart to offer people an identity with which to connect. This heart makes use of some existing irregularities and artificial ones to make them more natural. The apartment buildings in this green heart have a view over the district with lower blocks over the polder landscape and the Rotte River that lies behind Ommoord. The green heart and the view from the high-rise is the compensation for the people in the flats who lack their own outdoor space.[541]

Building-Site Preparation

At the beginning of the 1960s the first sand 'cunets' are laid out for the main road infrastructure. The infrastructure is laid directly on – and perpendicular to – the original polder allotment. The original landscape, the Ommoordseweg and Ommoordse Tocht (draining ditch) disappear under the layer of sand. The area is completely raised with 811,600 m^3 of sand.[542] To speed up the subsidence, vertical sand drains are applied.[543] This sand is brought by trucks and probably dredged from the Haringvliet. The soil from the bumps (the leftovers of the islands) is dug up and used elsewhere.

Between ±1963 and 1970 apartment buildings are built in the middle area of Prins Alexanderpolder. Around the flats the public space is heightened with black soil to keep up the public green. The surrounding

[540] Stam Beese no date, 3-4
[541] Damen and Devolder 1993, 87
[542] GAR secr. Afd. Openbare werken 465 179 lage land, Plan Rotterdam Oost, het Lage Land, Verzameling 1963 volgnr 370 OW 69255 B&W aan gemeenteraad
[543] GAR secr. Afd. Openbare werken 465 179 lage land, Plan Rotterdam Oost, het Lage Land, Brief stadsontwikkeling en wederopbouw aan b&W 29 juni 1967

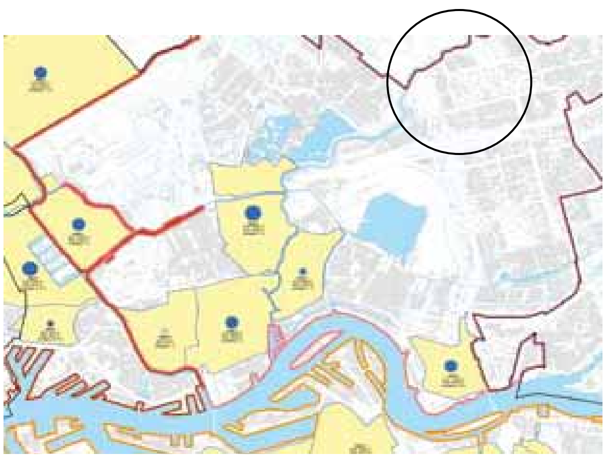
areas are usually filled in with 1 m of sand (except for the bumps) and low-rise apartments are built here. The south part is built between 1966 and 1972, the east part from 1970 to 1975 and the west part from 1971 to 1980 and finally the north part from 1978 to 1985.

Picture 5b.19 Areal view of Ommoord with in the foreground Zevenkamp (chapter 5c).
Source: Palmboom 1993

Ommoord in 2011

Just like Lage Land and many other post-war expansions in the Netherlands, Ommoord is also under reconstruction. Additional housing and modification of the public green structures are the common interventions. In Ommoord the public green especially is an undertaking because the residents experience it as suffocating.[544] The abundance of public green that Stam-Beese designed to give the area an identity is overgrown and is not maintained very well. It causes feelings of insecurity and makes the neighbourhood look shabby. Together with the residents, new public green is designed and the two shopping centres are renovated and additional housing is planned there.

In 2004 the municipality of Alexander decides to make a Water Plan together with the Water Board of Schieland and the Krimpenerwaard. An inventory is made to clarify what the issues are and in the Ommoordseveld water nuisance from rainstorms comes up. Part of the solution is to widen the water courses in Ommoord.



Picture5b.20 The Water Plan 2 mentions no water issues in the area but there is nuisance, and there is a quality issue.
Source: Waterplan 2

[544] Maandag 1993

The urban context of the plan and what the problem is with the rational building process are perfectly described by Lotte Stam-Beese. The urban context is completely artificial and structures and constructions are necessary to enable urbanity in this deep polder with soft soil. The relationship of the landscape and the water system to the new urban design is non-existent. The relationship between design and technology of building-site preparations does not exist either.

After the building-site preparation method of lowering the groundwater level is implemented in the Lage Land, in Ommoord once again the integral filling of the area with sand is used. The sand does not come from the Rotterdam harbours, but from the Haringvliet, which at that time is still in an open connection with the North Sea (closed in 1971). Complaints about salination are apparently not an object of discussion in this case.

The urban design of Ommoord reflects the international discourse on urban design on the one hand and the Dutch idea of the neighbourhood concept on the other. The use of large-scale apartment buildings that have a view of the original (cultivated) landscape as an asset that compensates for the lack of ground space is, as in the Lage Land, part of the idea of CIAM. The idea of a centre where the people can go to for primary facilities and meet is clearly part of the neighbourhood concept. Furthermore, the urban design is all that post-war urban design was: industrial buildings in step patterns with a lot of public green structures where the water is used as styling.

Picture 5b.21 Wilgenlaantje in Ommoord after a rainstorm
Source: W. Roos

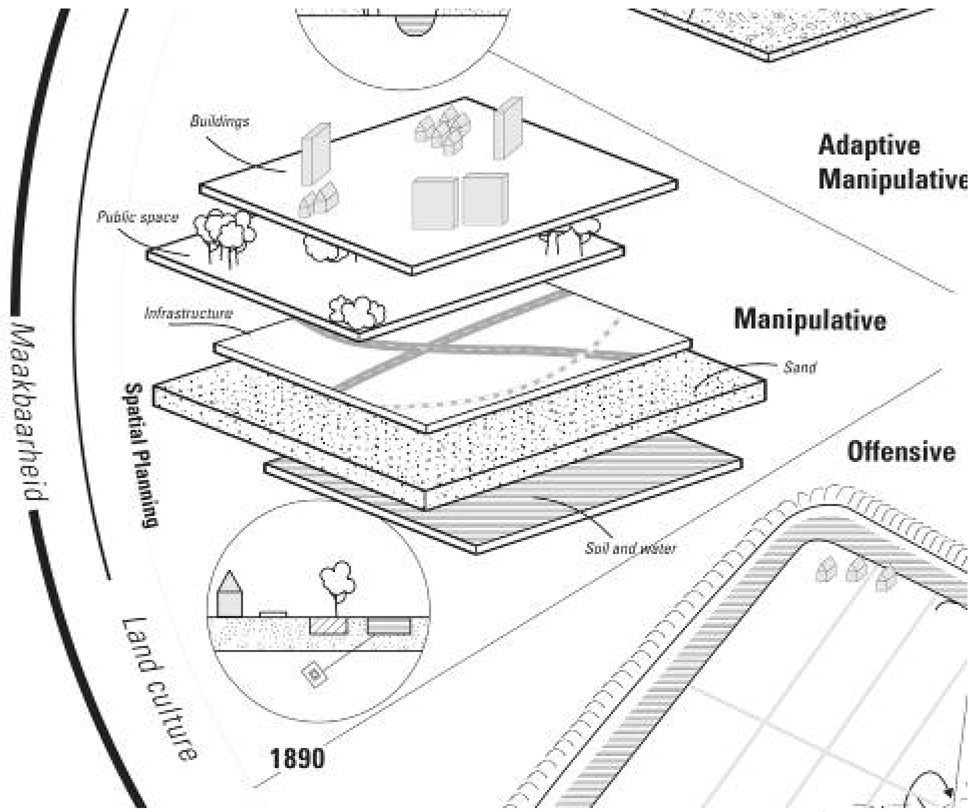
The Fine Dutch Tradition: Episode Five

The scale enlargement in organization and industrial city building is watertight in this episode. Technologically any characteristic of the territory, bad soil conditions, wet circumstances, can be attacked and harmonized for urbanization. Segeren and Hengeveld conclude: 'After the Second World War a number of developments considering city expansion and the need for housing leads to the consequence that little attention is paid to the soil conditions, water system and the landscape.'[545] Urbanization in the Netherlands is under pressure and industrialization makes it possible to

[545] Segeren and Hengeveld 1984, 29

realize large-scale projects and the integral hydraulic filling is an attractive method that fits the desired urban and industrialized scale. Also, due to shortage of time, it is practical to disconnect the urban design from the preparation of the site. For example the 'cunet' method means that from an early stage the layout is set, with integral hydraulic filling the plan can change (for example Blijdorp in chapter 5a).[546]

This practice of integral sand layers has negative effects on urbanism as Lotte Stam-Beese states clearly in the explanation to her design for Ommoord. She blames the efficiency and the technocratic approach, and like Webber and Rittel compares it to the classical systems-approach of the military.[547] The urban context is completely artificial and structures and constructions are necessary to enable urbanity in this deep polder with soft soil. The relationship of the landscape and the water system to the new urban design is zero. The relationship between design and technology of building-site preparations does not exist either.



Picture 5b.22 In the Manipulative Phase the accelerating manpower urban type of is characterized by division in fields of knowledge, each responsible for a different urban layer and producing an artificial urban principle.
Source: Author, drawn by Stella Smiek

The disappearance of the water is marked by the second industrial revolution, which produces an enlargement of scale on all layers: sand, roads, buildings, urban blocks and the urban pattern. It is part of the great shift in urban construction wherein the building block and the

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546 Segeren and Hengeveld 1984, 30
547 Webber en Rittel 1973, 155-169

infrastructure, the products of modern technology, determine the urban plan.[548] Water only pops up above the ground when it is adding to a recreational function. This trend builds up during this second stage during the Manipulative Phase illustrated by scale enlargement, industrialization, professionalization and the idea of the manmade culture and nature, the *maakbaarheid* paradigm: strict control becomes absolute. This process has an ambivalent relation to the Fine Dutch Tradition because it stands on its shoulders in using the body of knowledge, is perhaps a continuation, maybe even a logical continuation, but the perspective has shifted from the natural system completely and absolutely to the perspective of technology, the cultural perspective. And that, the detachment of the natural system, the layer of sand, marks a clear break with the Fine Dutch Tradition.

The maverick is the Lage Land that does show how extreme engineering can coincide with the original landscape structure, maybe the best example of a continuing of the Fine Dutch Tradition. Moreover, the conceptual idea of the vertical neighbourhood that is formulated for CIAM shows a magnified type of the Fine Dutch Tradition. The eventual realized plan is a simple and more applied form of this concept.

Most post-war expansions are integrally filled in with a layer of sand where the water system disappears and there is further enlargement of scale on all layers.[549] An interesting aspect of the urban design by Lotte Stam-Beese is that the dimensions of the polder landscape, as a never-ending structure, are applied in the dimensions of the urban plan, as a framework for 'swamp urbanism'.

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[548] Vanstiphout 2005, 256 citing: Van Eesteren 1923 Stedenbouwkundige Opmerkingen NAi archive.
[549] As described in the publications RIJP 1981, Biron 2005, and Segeren en Hengeveld 1984

Chapter 5c: Accelerating Flower Power (1970-1990)

Booming Awareness

This sub-chapter examines the third urban typology in the Phase of manipulation from 1970 until the start of the Phase of Adaptive Manipulation around 1990. This urban typology can be considered as the stepping stone to the next Phase.

The refinement of technology in the last decades of the twentieth century makes it possible not only to maintain that which is threatened, but also to take in an increasingly vulnerable place in the game between water and land; the perspective takes a (re)turn towards the natural system. Awareness that high technology makes us lose sight of what is vulnerable marks a cultural change at the beginning of the 1970s towards more attention for the environment and ecology. The publication by Rachel Carson, *Silent Spring* (1962), opens the world's eyes to man's bad influence on the natural system. The exhaustion of fossil fuels becomes part of the human consciousness through the oil crisis of 1973, and the Club of Rome (1972) throws light on the influence of humans on natural systems and puts the causal relation between economic growth and the effects on the environment in a clear perspective.[550] The hippies of the 1960s and 1970s are the ones to promote the ideal of a harmonious coexistence between man and nature: flower power.

Ecology becomes important within spatial planning and the notion of integral water management is canvassed.[551] It is assumed that ground and surface water must be managed in a physical sense as well-founded coherent systems (physically, chemically and biologically). Integral water management means a shift in regime for civil engineering. It leads to new objectives requiring new designs and working methods. It also means a strategic regrouping, as together with civil engineers, biologists and ecologists have also become players in the field of spatial planning.[552] Nature and ecology become more important in spatial planning and with this the landscape architect as a new player.

The third urban typology is comparable to Brown's waterway city, one of the six distinct, cumulative transition states in the development of urban water management in Australia.[553] The waterway city is concerned with social amenity and environmental health and point source and diffuse (storm water) pollution management is set up, instead of an end-of-pipe approach. This coincides again with the Dutch situation. The landscape architect reintroduces water as a spatial element in the city, bringing the amenity that

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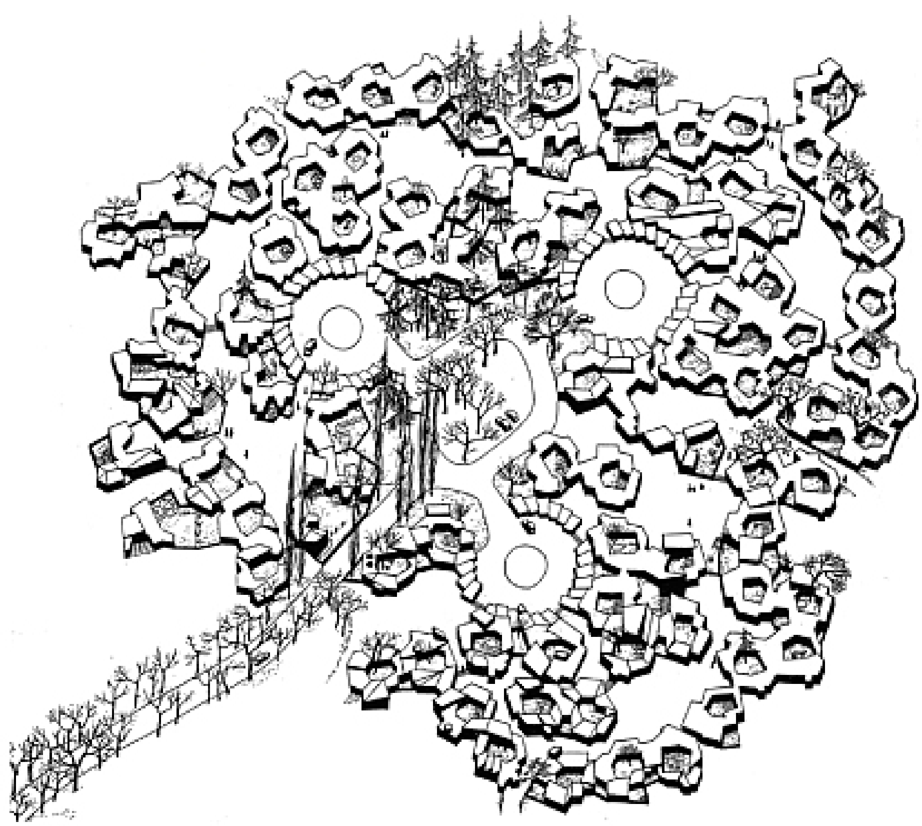
[550] Meadows 1972
[551] Van Leeuwen 1965, 1966 p 17
[552] Schot 1998, 63 and 181-192
[553] Brown et al. 2008

is missing in the post-war era. This era is considered a time of technocracy and narrow-minded views on social structures. There is a strong urge to free society from these conventions and a search is made into the real identity of the city. The search for an urban identity also helps in bringing back water, because it is found in the old water towns and plans for reopening filled-in water are made.

The city types produced in this urban Phase are diverse, best known are the so-called 'cauliflower' neighbourhoods that have an ingenious weaving of infra structures, green and water with amorphous housing and cul-de-sacs. New methods of building-site preparation make it possible to once again integrate original landscape structures in the city. Besides their contribution to the desired morphology, this also connects to the quest for identity that is important within the spatial order.

In Rotterdam the cases Zevenkamp and Prinsenland are investigated. In Zevenkamp an old ditch is restored in the layer of sand for the identity part of the urban design. It is an example of the transition towards the more environmental approach to urban development. In Prinseland a combination is made using the identity of place in existing urban and landscape structures in a strategy called: Urbanized Landscape. The new method of applying partial sand layers to preserve landscape structures in the areas to be newly developed is part of this strategy.



Picture 5c.1 A 'cauliflower' neighbourhood drawn by Niek de Boer (landscape architect), 1972
Source: Niek de Boer

'Cauliflower' Neighbourhoods

The term 'cauliflower' refers to the morphology of these areas, which are very mono-functional: housing. The cauliflower structure is derived from the road infrastructure that is designed in such a way that all traffic is slow, with the use of *woonerven* – home zones. The natural shapes of water and green structures and the design of houses with a lot of corners and non-square forms are also the basis of the name cauliflower.

The Third Report on Physical Planning of 1975, refined in the Structural Outline for Urban Areas of 1985, uses 'gedecentreerde concentratie' (decentralised concentration) as a steering concept and towns are selected that are supposed to grow to provide enough housing for the increasing population: Alkmaar, Almere, Capelle aan den IJssel, Duiven, Etten-Leur, Haarlemmermeer, Hellevoetsluis, Helmond, Hoorn, Houten, Huizen, Lelystad, Nieuwegein, Purmerend, Spijkenisse, Westervoort and Zoetermeer. The measures for the realization of the 'centres of growth' are formulated in the 'Verstedelijkingsnota' of 1978 (Urbanization Report).

Picture 5c.2 Typical 1970s (close to cauliflower) urban tissue, here showing how the lake for sand is integrated with the new neighbourhood.
Source: Dufour 1979

It is interesting that the report stipulates that the new residential areas need to be located in areas with good soil conditions and that existing landscape elements are to be incorporated in the urban plan; particularly to prevent the high costs of building-site preparation. For most built-up areas at that time this is not the case. Provinces make regional plans that include an assessment of the soil conditions and the source of sand with which to improve the sites. There is usually no attention paid to the method of building-site preparation and land values.[554] Then a structural plan in which the future developments are set out, a framework for infrastructure, housing and landscape and a frame for the zoning and development plan is made by the municipality.[555]

Picture 5c.3 Aerial view and cross section of Beverwaard, just like in the Jordaan in Amsterdam every other ditch is closed and the remaining widened. The back yards are lifted to create parking facilities.
Source: Aeroview

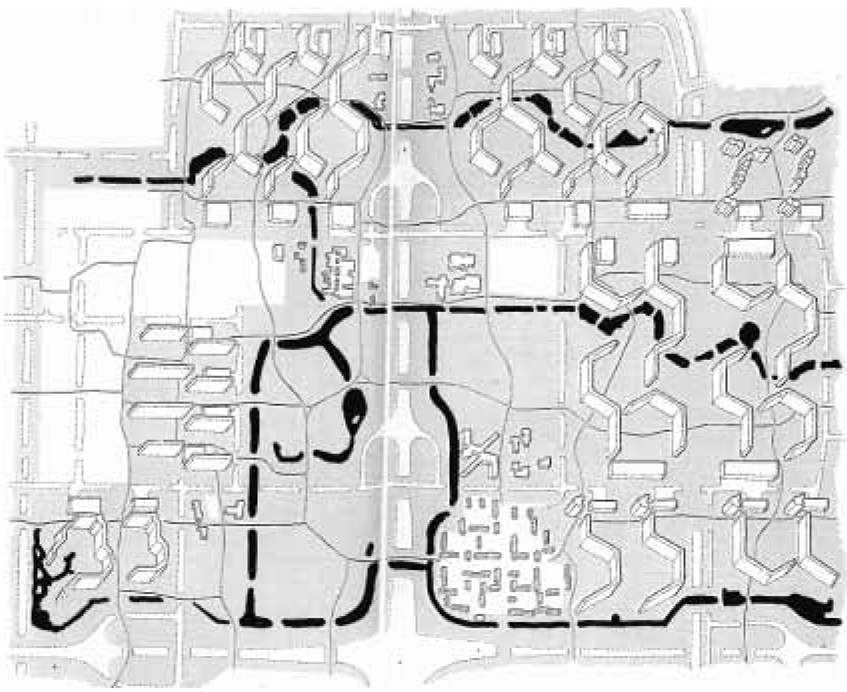
Next the municipality makes a zoning plan; this is the only legally binding spatial plan in the Netherlands. It is a more detailed structural plan that presents the economic and technical and formal aspects of the urban design. For building-site preparation it presents the chosen method with technical details like the filling (where, amount of sand, paved surface) and drainage system (principal, sewer) and the detailed division of the land in lots.[556]

After the period from 1965 to 1970 in which the accent is placed on technocratic aspects like efficiency and sufficient housing built on a layer of sand that provides artificial green structures and water, from 1970 the human scale returns, and with it an integration of functions and historical

[554] An example is: P.P.D.-Utrecht, Bodemgeschiktheidsbeoordeling voor stedelijke gebieden in de provincie Utrecht, Utrecht 1980 and P.P.D.-Noord-Holland, onderzoek kosten bouwlocaties in Noord-Kennemerland. Interdienstelijke werkgroep voorbereiding herziening Streekplan Noord Kennemerland, Haarlem 1981
[555] Segeren and Hengeveld 1984, 34
[556] Segeren and Hengeveld 1984, 35

values.[557] Former polder ditches become interesting as a design framework, as in the Beverwaard, and water is once more seen as a structuring element.[558] In contrast to the sober *singels* of the reconstruction of the Netherlands, the natural character of the green belt and water suit the residential areas built in the 1970s perfectly. Residences are located in courtyards and encircled by green structures with *singels*. In the water structure design and profile, the natural character of the water is well used.

In this period, nature-friendly banks come into fashion, which give the *singels* an entirely different appearance. Influenced by books such as *Silent Spring* (1962) by Rachel Louise Carson, more attention is given to ecology. Carson describes how the use of modern herbicides resulted in over-cropping and deformation of the plant world. Her book inspires designers to see nature and city more as an integral issue rather than looking at them as two separate worlds.[559]



Picture 5c.4 Plan of the Bijlmermeer that shows clearly how the water structure is part of the 'natural' landscape in which the megastructures are situated.
Source: Municipality of Amsterdam

The new approach towards nature and the desired living circumstances is also expressed by altering the standard way of preparing building sites. Instead of covering the entire area, the partial method offers the possibility of preserving original landscape structures within the urban tissue. Public green structures and gardens are not covered in sand (on which nothing grows) and only the streets and houses are constructed on a sand layer. Besides the partial method of filling, other new techniques for building preparation come into use. The application of lightweight materials such as

[557] Segeren and Hengeveld 1984, 36
[558] Segeren and Hengeveld 1984, 229
[559] See Carson 1962. Silent Spring initially appeared serialized in three parts in the 16 June, 23 June and 30 June 1962 issues of *The New Yorker* magazine showing the social interest in this theme.

polystyrene foam and granules has the advantage that building can start immediately and that little subsidence occurs afterwards. In some cases the method of complete foundation of streets and buildings is applied: the elevated living platform method, where the disconnection between the surface and the construction is a fact.[560]

The Bijlmermeer in Amsterdam is the earliest example where the confrontation between nature and culture is developed in a city plan. The urban project of infrastructure, housing and nature are pulled into three pieces, all with their own logic. The infrastructure is completely disconnected from the public green and the housing in large apartment buildings is also disconnected. Bijlmermeerpolder is a very wet polder that is prepared for building by applying a layer of 4 m of sand (over the original drained lake structure).[561] The public green is designed on top of this layer as a natural park, on this layer the buildings and the infrastructure (elevated like the living platform method) are placed both with their own logic and on different scales.[562]

Picture 5c.5 The Chinese Wall in Capelle aan den IJssel in the background and the small-scale housing in the peat polder in the foreground.
Source: Tim Eshuis

The megastructures of the Bijlmermeer suit the ideas of the CIAM, who see these as the result of the uncontrolled growth of the city.[563] Another example of these megastructures and their relation to the landscape is the 'Chinese Wall' in Oostgaarde (Capelle aan den IJssel). In 1965 the Oostgaarde is ready for building and on this tabula rasa a large wall of huge apartment buildings is created. The adjacent strip of peat polder, which is untouched due to a reservation for a national highway, is in sharp contrast with this urban development protocol, which lost each and every element of landscape

[560] For the more specific conditions of this development see Grontmij (1980), Rijksdienst voor de IJsselmeerpolders (1981) and Stichting Bouwresearch (1985).
[561] De Hoog 2005, 80
[562] Heeling et al. 2002, 157
[563] See DeYong et al. 2002

identity. In this urban development concept this strip emphasizes the relation with the adjacent Prinsenland, where the team of Urban Development and Public Housing service (including Frits Palmboom and landscape architects B&B) concentrated the spatial planning on a confrontation of old and new structures. The long dike and the peat reclamation strips, which have been preserved in Oostgaarde by accident, are used as structuring elements of the urbanized landscape in Prinsenland. It is an example where the historical structures of an area and a specific approach towards the method of building-site preparation can produce a whole new urban strategy: urbanized landscape.[564] This case is described in this chapter.

Building-Site Preparation after 1970

In 1977 a study is done into the methods of building-site preparation, *Onderzoek naar de wijze van bouwrijp maken van terreinen in een twaalftal gemeenten in Nederland* (Research into methods of building site preparation in twelve municipalities in the Netherlands). The investigation is done by ing. W. Van Dijk and ing. A. Overwater (IJsselmeer Polders Development Authority) and ir. H. Hengeveld (Delft University of Technology, Civil Engineering). More knowledge about building-site preparation is crucial for the building of the new towns Lelystad and Almere. The common method is used in the new Flevopolder: on the soft clay of the former Zuiderzee floor, 1 m of sand is filled in and then it is drained. The research into ten cities delivers information about the winning of sand, of soil and finances. The most memorable findings of this story are:

1. The practice of building-site preparation is very much determined by the local knowledge with the municipal departments of public works.
2. The street level is determined on the drainage level, this freeboard varies in the different municipalities from 0.90 cm to 2 m above drainage level and most commonly between 1.00 and 1.30 m.
3. The choice between the 'cunet' method and integral filling with sand is dependent on an optimal drainage for the lowest costs. The height of the filling is dependent on the drainage level (the freeboard) plus the expected subsidence.
4. The start of building-site preparation is between one and three years before building starts.
5. In Amsterdam, Delft and Rotterdam no sub-surface drainage system is applied; in Rotterdam a leaking sewer system is expected.
6. Surface water is mostly for storage and thus calculated as such. In just a few cases the surface water is also used as discharge. Level fluctuations are not motivated in any of the cases.
7. The distance between the water courses varies from 200 to 800 m

[564] Palmboom 1987 and Bakker en Bleeker 1983

– this is dependent on the function. In Amsterdam and Delft the water courses are for groundwater drainage and have a distance of respectively 600 and 200 m.

8. Most cases choose a separate sewer system.[565]

These findings show that there are enough varying aspects of building-site preparation to make the practice of it very different from city to city. It is interesting to see how in Rotterdam, the city where the development of knowledge is very actively pursued, the methods are evaluated. The report 'Bouw- en woonrijpmaken in Rotterdam' (Building-site preparation in Rotterdam) is written in 1984 to evaluate three alternative methods compared to the common methods.[566] These are developed in the 1970s due to the desire for more ecological methods and to keep the landscape characteristics available for the urban design.[567]

The report evaluates polystyrene (0.3 kN/m^3) and other lightweight materials. Compared to normal sand (20 kN/m^3) these are much lighter and put less pressure on the peat layers and therefore causing less subsidence. Polystyrene is the lightest and the most appropriate candidate for building-site preparation because it has high coherence, stability, water absorbing capacity and is temperature durable. At the time the only experience with polystyrene was above groundwater level, but the Department of Public Works tested the floating capacity of polystyrene under groundwater level.[568]

The positive aspect of the alternative methods is that the site can be developed in a fragmented manner, sewer and temporary roads can be constructed just before building the houses, there is, in theory, no subsidence. A negative aspect is that some and irregular subsidence does occur; also that the material needs to be added when some ground works are done, that the change of urban plan is very costly, sewer connections to houses are vulnerable, an interrupted water system and problems with the drainage of green areas.[569]

Another evaluated method is the 'living platform', a platform on foundations for the houses and the street to which the cables, sewer and pipes are attached. The platform is built 1 m above *singel* level (surface water level), the gardens are on the original ground level without filling and parking lots are on a polystyrene layer. This construction means that the groundwater level needs to be regulated with surface water, sub-surface drains, sewers and pumps. A rainstorm that causes a 20-cm rise in groundwater level (at that time estimated to happen once every 15 years) can be overcome, but the report advises the building of a spare *boezem* when the discharge capacity of the polder is low. As a consequence the surface water area in the site should be about 6 or 7 per cent. Positive factors of this method are that the site does not need to be completely available, building can start right after the building of the platform, the whole site will have foundation piles, green structures can be used in the new plan, the water system can be maintained and sewer connections to the houses are not at

565 Van Dijk et. al. 1977, 1-8
566 Gemeentewerken Rotterdam 1984, 7-8
567 Segeren and Hengeveld 1984, 31
568 Gemeentewerken Rotterdam 1984, 19-22
569 Gemeentewerken Rotterdam 1984, 24

risk of breaking. Most negative aspects are that it is very expensive and that in the future it becomes very difficult to change the urban tissue. The urban plan needs to be detailed from the beginning and changes are very expensive. The water system needs some adjustments in case of level fluctuations as explained above.[570]

The final evaluated method is lowering the groundwater table in combination with sand in road strips (cunet) transported by truck with vertical drainage.[571] The argument is that by lowering the groundwater table only a thin layer of sand is necessary to have 1 m of drainage level. Negative aspects concerning groundwater level lowering are the chance of pile rot with existing structures on wooden piles, the adjustment of the water system to this building of a polder within a polder (culverts, pumps and surface water), increasing seepage, subsidence and the start of an irreversible subsidence process. These aspects make the writers of the report conclude that this method is not useable in Rotterdam.[572]

Another new material with which to raise sites is foam concrete – a mix of cement, water, foam products and air. This had already been invented in the nineteenth century but was not used until the beginning of the 1970s.[573] In 1993 consideration is given to the use of foam concrete as means to raise sites instead of sand.[574] The concrete foam is usually used as the top layer, on a layer of polystyrene foam; together this makes a much lighter layer than sand. The weight of sand is about 2000 kg/m^3 while the polystyrene and concrete foam together weigh only 600 kg/m^3. This is convenient in very soft soils where subsidence is a recurring problem.

In 1985 the Stichting Bouwresearch (Building Research Foundation) publishes the report, *Snel Bouwrijp maken, een zettingsvrije methode als alternatief voor integraal ophogen* (Fast building-site preparation, a subsidence-free method as alternative for integral filling) that is, as the title states, a way to prepare a site without filling it in. The starting point in this method is keeping the original balance between soil and water. No pressure can be put on the site and the existing drainage system will be maintained. This way subsidence will not occur.[575]

The use of lightweight filling materials, such as polystyrene, makes this way of building site-preparation possible. Roads, parking lots, walkways and terraces are situated on this material and dimensioned in such a way that there will not be any subsidence. The rest of the area will be garden and public green so it can keep its original character. This method is especially convenient for weak clay and peat. It is important to have a detailed urban plan at an early stage for this method.[576]

Gardens and public green will not be filled in so the freeboard will be only 30 to 50 cm. The bow in the phreatic groundwater level will get as close as 25 cm to the surface. These high groundwater levels put certain restraints on the design and use of these green areas.[577] The problems with the high

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[570] Gemeentewerken Rotterdam 1984, 24-25
[571] Gemeentewerken Rotterdam 1984, 25-26
[572] Gemeentewerken Rotterdam 1984, 25-26
[573] *De Ingenieur* (1972) no. 11, 48
[574] *De Ingenieur* (1993) no. 2, 45
[575] Stichting Bouwresearch 1985, 8
[576] Stichting Bouwresearch 1985, 9
[577] Stichting Bouwresearch 1985, 29

groundwater level can be solved by applying sub-surface drains. In the 1970s the development of plastic drains makes installation easier and cheaper. Rotterdam remains ahead of new developments. In 1994 a subsidence map is made that shows the details of the whole Rotterdam area. This is not a new idea; former director of Public Works Burgdorffer had already suggested this in 1919.[578]

Rotterdam Zevenkamp

The *Verstedelijkingsnota* (Urbanization report, 1979) puts pressure on the municipalities to provide their inhabitants with proper housing, to prevent them from moving to smaller municipalities. In this report some guidelines are added about the type of soil and water conditions of the areas that are chosen to be urbanized. The new residential areas have to be situated in areas where the soil and water conditions are reasons to preserve the original landscape and use it in the new urban design, and where high costs of building-site preparation can be prevented. In practice this never becomes a reality, of the 14 chosen locations for extensive urban development, 12 are in polders where the freeboard (difference between the groundwater level and ground floor level) in wintertime is between 0 and -50 cm; and the soil consists of a thick layer of highly compressible clay and the sub-soil contains soft peaty layers.[579]

Picture 5c.6 Urban design for Zevenkamp
Source: Municipal Archive Rotterdam

Rotterdam expansion further north towards Zevenhuizen becomes possible after a very long debate with the neighbouring municipality Capelle aan den IJssel, resulting in a deal exchanging grounds in Prinsenland. Some of the municipality of Zevenhuizen's land is also needed. The grounds can be annexed, but a buffer between the new area and the original ribbon of houses along the Wollenfoppenweg is one important condition.

The city expansion is planned on a very weak and wet territory that is

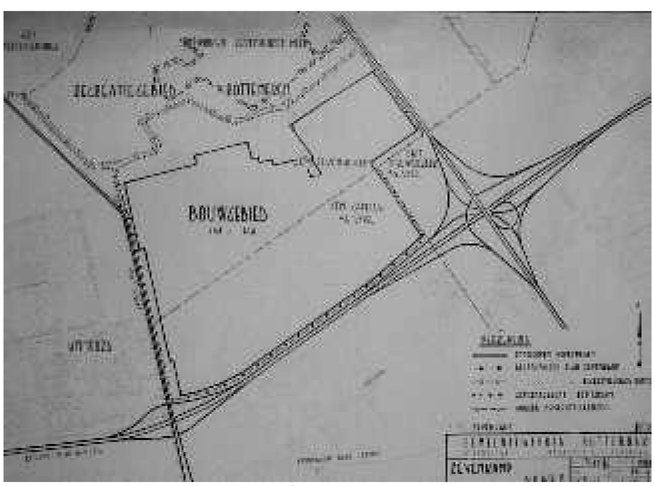
[578] Department of Public Works 1919
[579] Gemeentewerken Rotterdam 1984, 10

known as very difficult to build on. In technical reports the soil is described as a thick layer of easily compressible clay and peat, a qualification that can be translated into: an area of 220 hectares of thick water!

In the Netherlands it is common to prepare sites on clay soil with the 'cunet' method and soft clay and peat grounds are integrally filled in with sand. In Rotterdam sites are prepared using the cunet method until 1965, filling the streets 1.00 m above polder level. Because of the problems associated with this method, the choice is made in Zevenkamp to prepare the building site by filling in the entire area with sand.Therefore in Zevenkamp after some investigation integral filling with sand is chosen.[580]

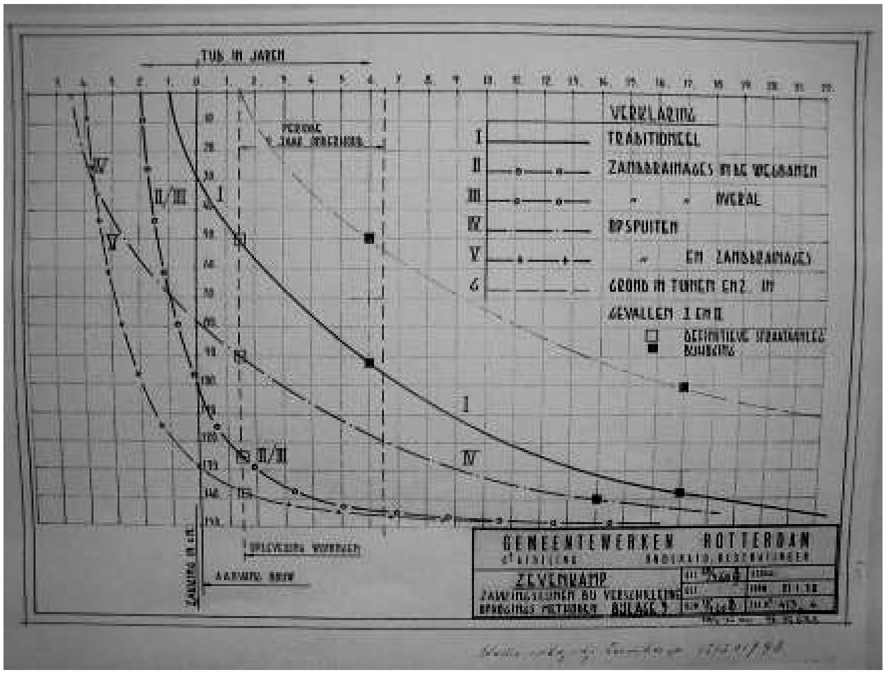
Zevenkamp is situated 6 m below MSL and to a depth of 7 to 10 m it consisted of highly compressible peat and clay. By 1967, the Department of Public Works has started investigations into building-site preparations of the site. The timetable in picture 5c.8 shows the different methods of building-site preparation and their subsidence speed. The Department of Public Works also makes a serious proposal to use foundation piles, also for the underground infrastructure, instead of integral filling. Because sand is easily available by digging a lake in the Eendraghtspolder close by, the choice is made for fill in the entire area. The resulting lake will serve as a recreational area and the sand surplus can be sold to Capelle aan den IJssel to use in Oosterflank and Schollevaar. In this way the lake generates income to pay for the development of Zevenkamp.

In total 53 million m^3 soil and 11 million m^3 sand is taken out of the Zevenhuizerplas. In Zevenkamp a layer of 1 to 2 m is applied. By the use of vertical and horizontal drains the subsidence process is speeded up. A year after the sand layer is built, construction on the sewers and city heating in the western part of the plan commences. Between 1973 and 1978 the whole area is filled in and it takes from 1980 to 1995 to realize the urban plan. A layer of clean garden soil is applied on top of the hydraulically filled in sand layer in the green structures and gardens.[581]



Picture 5c.7 Building area of Zevenkamp showing the structure of the highway, roads and the recreational area. Also showing the area that will be hydraulically filled. 413-3 1968
Source: Archive of Public Works Rotterdam

[580] Segeren and Hengeveld 1985, 132; and Gemeentewerken Rotterdam 1968.
[581] Van Dijk et. al. 1977, annex 10



Picture 5c.8 Showing the different methods of building-site preparation and the time it takes to subside before building can start. I is traditional with Cunet method, II is traditional with sand drains only under the roads, III is traditional with sand drains everywhere, VI is hydraulically filling and V is hydraulically filling with sand drains.
Source: Archive of Public Works Rotterdam

Urban Plan

Due to the fact that the urban designers of the municipality of Rotterdam are busy with the urban renewal of inner-city areas built in the nineteenth century, an urban design office is hired to make the development plan. In 1976 Joost Schrijnen has just started at the Amsterdam office of architecture and planning Abma, Hazewinkel and Dirks when he is commissioned to design Zevenkamp together with landscape architect Riek Bakker.[582] Their assignment is to design a city expansion that can compete with the neighbouring green municipalities, to where most city dwellers are moving at that time. It needs to have a small scale and green character with many ground-bound houses for families and housing for senior citizens. The constrictions with which they have to work are the highway situated at the south border and the projected exit. On the north side of the area bordering Zevenhuizen, the park buffer needs to be situated, and the brief is to design around 6,500 houses, the subway that connects the area with Rotterdam city centre, 50 per cent ground-bound houses and 50 per cent stacked houses, utilities, housing for senior citizens, schools, sports facilities, and so forth. The Department of Public Works starts by filling in the grounds with a layer of sand and the designers are instructed to create a plan with 3 to 4 per cent open water and 25 per cent paved surface area.[583]

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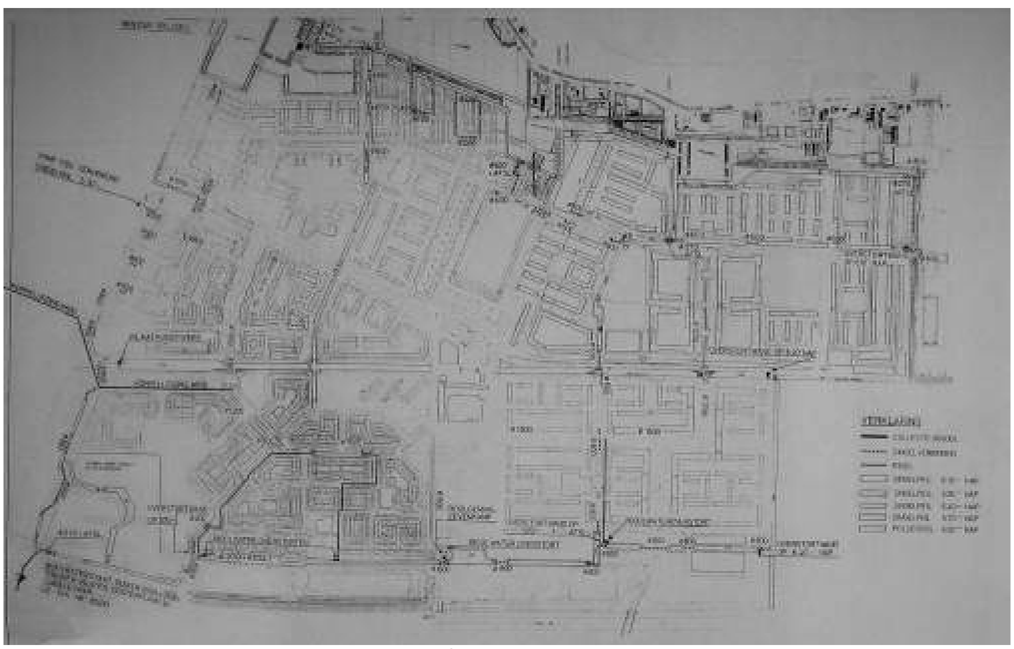
[582] The following paragraph is partly based on an interview with Joost Schrijnen by the Author on April 3rd 2008
[583] Van Dijk et. al. 1977, annex 10

Schrijnen and Bakker structure their urban design around the original Ommoordse Tocht that flows right through the area with, perpendicular to these, five other *singels* spread over the width of the area, intertwined with the road infrastructure. They all drain into the canal along the highway that serves as a discharge basin (also for combined sewer overflow) and connects on the north side with a waterway. The schools and bicycle paths are situated along the *singels*.

The second main structure is the obligatory green buffer on the north side: Wollenfoppenpark. A lot of effort is taken to design this park in consultation with the owners of the houses in the ribbon. A north-south axis is placed connecting the Wollenfoppenpark through the centre with the highway. This city park is accentuated by a dike.

The main centre of Zevenkamp is placed where the Ommoordse Tocht and the subway, the third important structuring element, intersect. The subway and the location of the stops functionally order the plan. Utilities are situated around the stops (first two, later three) and a ring road connects the stops and forms the main road infrastructure (unfortunately the ring has not been closed so far).



Picture 5c.9 The water management plan of Zevenkamp 82217 23 July 1982
Source: Archive of Public Works Rotterdam

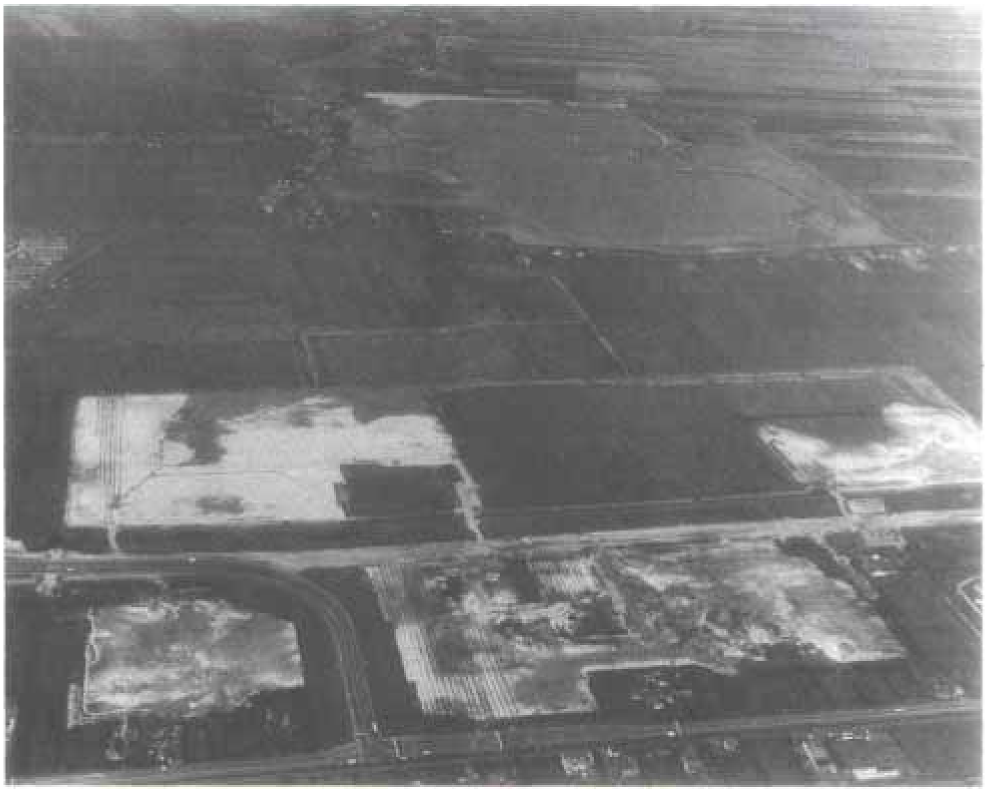
During the building-site preparation a temporary water system has to be put in place because Zevenkamp is in the flow of water coming from the Rotte and going to Oosterflank, Zevenhuizen, Nieuwerkerk aan den IJssel and Capelle aan den IJssel. This is later used as an extra system offering extra storage capacity. Water in the sewer is collected in a large collector on foundation piles near the pumping station in Zevenkamp. From there it is pumped to a station in Schollevaar.

The *singels* are very important spatial structuring elements in the plan and the water system has to be constructed in a special way. Because of the high pressure of the deeper groundwater in this polder the soil is pushed upward and becomes unstable, like quicksand. That is why the bottom of the *singel* needs heavyweight soils, to bring back the balance before digging. A thick layer of sand is therefore installed at the bottom of the *singels* in Zevenkamp.

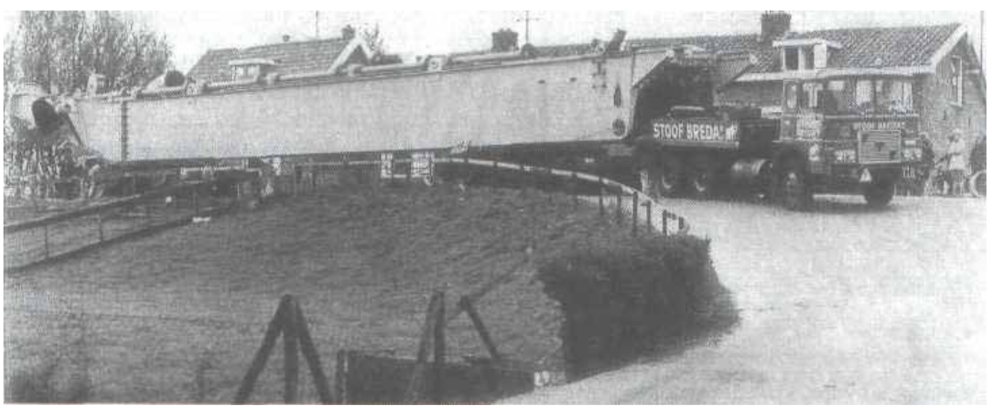
The Ommoordse Tocht is designed as a canal with quays when it crosses the main centre of Zevenkamp. This is done because the green *singel* takes up a lot of space and the urban designers situated the shops on each side of the canal to be closer together and nicely connected by four bridges across the canal.

Around 1990 Wollefoppenpark is built on the northern border of the (then fully built-up) Zevenkamp area. The ribbon of houses is separated from the layer of sand to preserve its original character.

Picture 5c.10 The contour of the new lake is visible.
Source: Municipal Archive Rotterdam

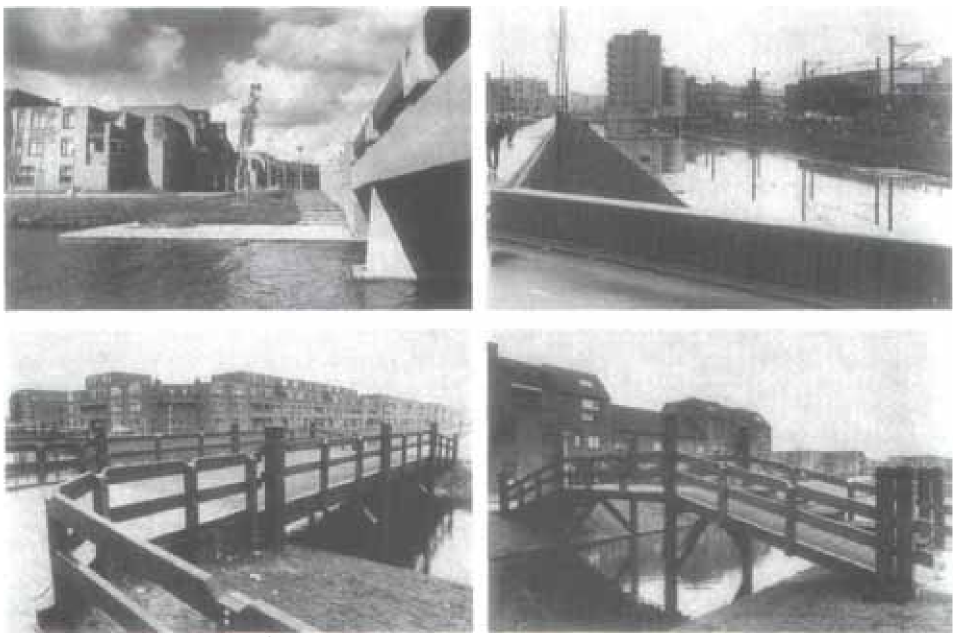


Picture 5c.11 Here the connection between the lake and the preparation of the building site is visible, both without relation to the original landscape.
Source: Municipal Archive Rotterdam



Picture 5c.12 A pump for hydraulic filling is transported over the small agricultural roads. Because the pump is too large to be transported whole, it is taken apart and reassembled on location.
Source: Municipal Archive Rotterdam

Picture 5c.13 First houses are built.
Source: Rotterdams Dagblad



Picture 5c.14 Detailing of the waterway Ommoordse Tocht.
Source: Municipal Archive Rotterdam

Zevenkamp in 2011

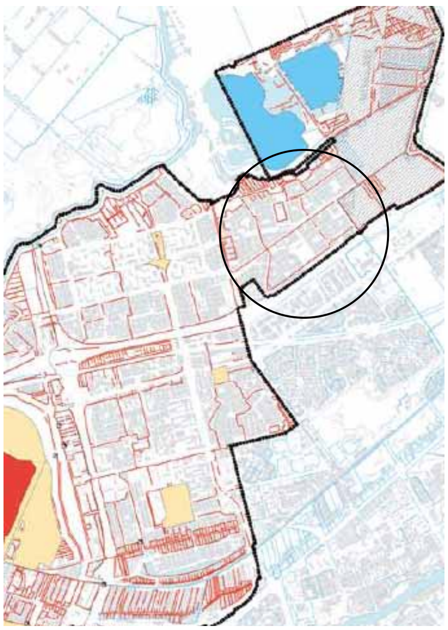
The urban design of Zevenkamp takes no account of the original polder allotment of the former agricultural landscape, except for the Ommoordse Tocht that is used as a structuring principle and the ribbon of houses along the Wollenfoppenweg that forms a buffer with the neighbouring municipality.

The area can still be recognized as a clear unit in the drained lake, prepared with an encompassing layer of sand to be used as a living area.[584] Even though those involved are aware of the possibilities of partial filling and the importance of green structures in the area, the choice for integral filling is made on a financial basis. The bad soil conditions are 'solved' with a layer of sand in combination with drainage systems and water structures.

[584] Anonymous 2002

The relationship between the original landscape and the water system is therefore reduced to the Ommoordse Tocht, which forms an extensive green structure and connects the two neighbourhood parks and the green buffer at the north border.

The municipality of Prins Alexander prepared a Waterplan to improve the water quality in the area and do something about recurring water nuisance (flooded cellars). These measures also apply to Zevenkamp, where water nuisance specifically occurs in the Zuidelijk Wijkpark. For the quality improvement of the water system Noordelijk Wijkpark will get nature-friendly banks. The Ommoordse Tocht will also get nature-friendly banks in some places and floating gardens.



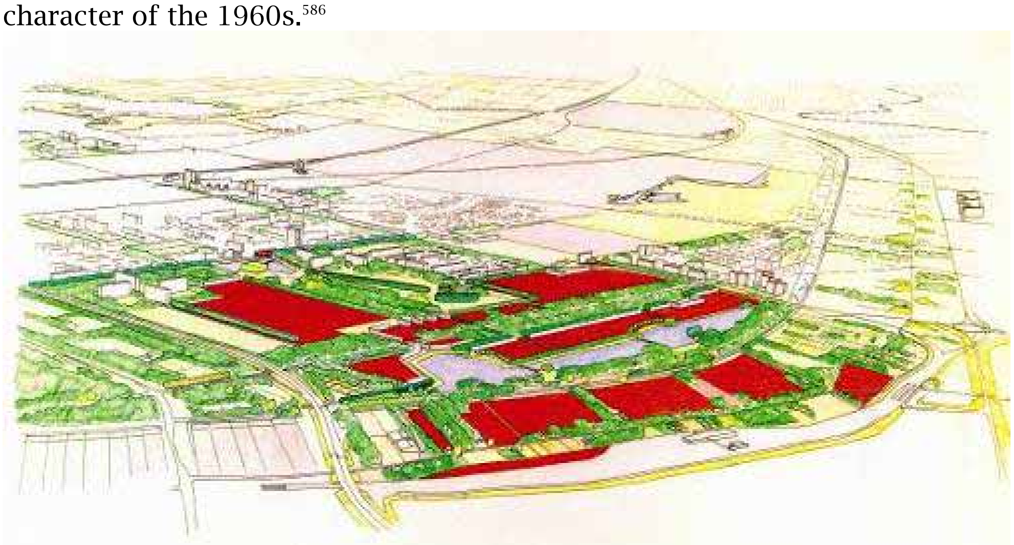
Picture 5c.15 Waterplan 2 mentions no water projects in the area, but there is a quality issue
Source: Waterplan 2

Typical of Zevenkamp is the lake dug to provide sand. This is seen in many Dutch polder cities. By the use of the integral filling method the relationship between urban design and the technology of building-site preparation is non-existent. The urban design is typical of the 1970s with its mix of housing, use of diagonals and cauliflower-like shapes for urban blocks. Besides the Ommoordse Tocht, five other *singels* are used to structure the area in association with the parks. This case shows a first step in the return of landscape and water as instruments of design. The case shows a glimpse of the Fine Dutch Tradition.

Rotterdam Prinsenland

Prinsenland as part of the Alexanderpolder has as a main structure, the 's Gravenweg, the dike in the reclamation pattern with the Hollandsche IJssel as base. It is closely connected to the earlier developed Lage Land and is mainly used for horticulture. The first greenhouses are built in the 1920s and within a short period of time the whole area becomes covered with glass. The cemetery is situated In the middle of the area, raised with a few metres of sand. In the 1960s the area is characterized by the ribbon development of farmers' and labourers' dwellings and other activities along the 's Gravenweg, Ringvaartweg, Kralingseweg, Kralingse Kerklaan and Turfweg.[585]

Prinsenland is situated partly in the drained lake Alexanderpolder, which is low lying, and partly in Bovenland, which is higher because peat was not extracted there. The lower part has the typical orthogonal structure of land reclamation; Bovenland has an irregular pattern of ditches and roads and is subdivided in a different direction. The area has four parallel ribbons, Prinsenlaan, Kralingseweg, Ringvaartweg and 's Gravenweg, perpendicular to the north-south oriented subdivision. The Kralingseweg is the backbone of Alexanderpolder, most urbanized with different functions and typologies. The Ringvaartweg is the border between the drained lake and Bovenland and marks the different landscape on both sides. It has a more countryside-like character, a soft curve and shows the height difference and the different water levels. The 's Gravenweg is the backbone of Bovenland and makes a gentle transition from east to west, from countryside to city. The south side is bordered by the subway track and an excavated mud depot. The Prinsenlaan is the main exit from Lage Land and has the typical large-scale character of the 1960s.[586]



Picture 5c.16 Bird's-eye view of the new urban design of Prinsenland, by Frits Palmboom
Source: Palmout Urban Landscapes

[585] Anonymous 2002
[586] Stadsontwikkeling Rotterdam 1983, 4-5

Prinsenland was part of the studies of Alexanderpolder by the Opbouw in the 1950s. The last large part of Alexanderpolder is designed in 1984 and presented in the Structural Outline Prinsenland. Just as then, the plan functions as a testing ground for different ways of thinking about the city: in this case the transformation of an already urbanized landscape. The key concept of Prinsenland is the reinterpretation of its context, the position of the city in its own morphology as a link between old and new. The differences in the characteristics of the territory are used as guiding concepts in two different urbanization principles: one is the large scale in the northern section, the deep lying Alexanderpolder; and second the lot-by-lot development in the southern section, the strip of fan-shaped allotments along 's Gravenweg. The contrast between the two is stressed by the new lake that puts the accent on the long curved line. Besides the large-scale interventions, the existing ribbons are integrated in the plan and lot-by-lot development allows them to retain their own dynamics. The plan organizes and allows development on a large scale and lot-by-lot: simultaneity is the keyword of the plan.[587]

For the new urban design the following aspects are taken as guide, interestingly all have a relation to the physical geography of the area:

- The identities of Bovenland and Alexanderpolder (polders);
- The Ringvaart as a dividing element (water system);
- Protect the curve in the Ringvaartweg by openness (height difference);
- Continue on the variety of spatial compartments (dikes and height differences);
- Preserve the open character of the polder between the Kralingseweg and Prinsenlaan and enrich it with a varied spread of autonomous elements;
- Respect the specific character of each ribbon: Kralingseweg (backbone function, new small-scale development), Ringvaartweg (protect countryside character), 's Gravenweg (development per plot, city border activities), Prinsenlaan (appreciate as ribbon, east-west route for slow traffic, better connection between Lage Land and Prinsenland);
- Hierarchy in structure: highest level continuity in east-west direction, lower level variation in north-south direction.[588]

Prinsenland is to be a residential area for 5,500 houses and a green structure with a park and a lake connected to the existing recreational zones. The part on the north side of the Ringvaart has the Kralingseweg as its main structure and the new Kralingse Achterweg as the main exit route. The northern areas Prinsenparkbuurt and Dosiobuurt are connected with the new park and the southern area Ringvaartplasbuurt with the new lake. On the south side of the Ringvaart, along the 's Gravenweg, smaller-scale areas develop, alternating with existing uses. These areas are also oriented on the lake. Along the ribbons the existing buildings are kept and current land use continued. In addition to housing and the park there is room for special and business use.[589]

[587] Palmboom 1993, 41
[588] Stadsontwikkeling Rotterdam 1983, 7
[589] Stadsontwikkeling Rotterdam 1983, 9

Building-Site Preparation as Urban Design

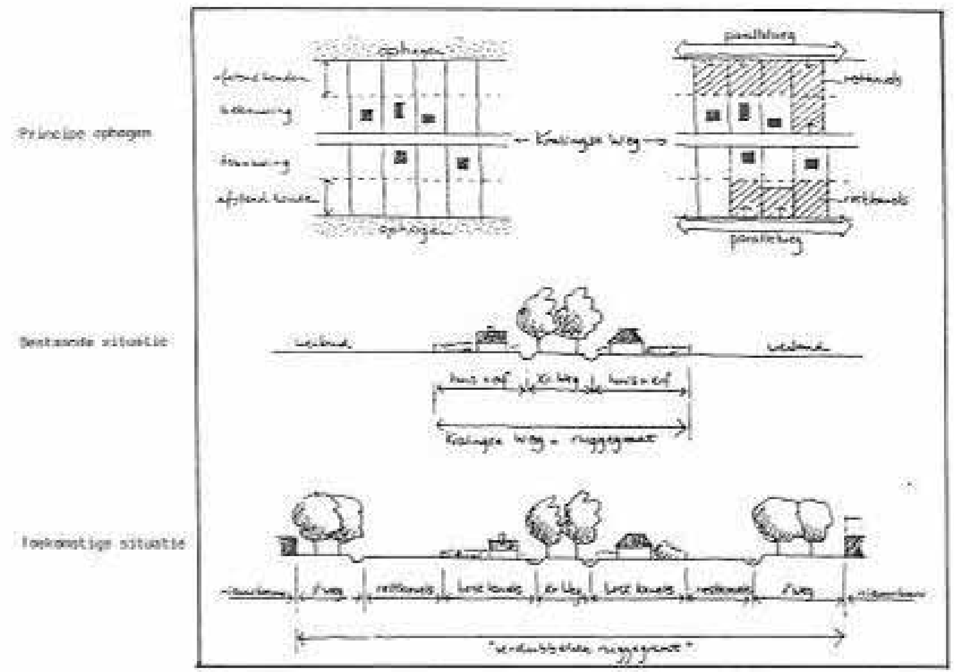
The strategy of 'urbanized landscape' means that a large-scale development with an encompassing layer of sand, like in Ommoord and Zevenkamp, is not possible. Additionally, the height differences between the northern and the southern side do not make this a useful strategy. In the neighbouring district Lage Land, groundwater level lowering is applied (see chapter 5b) so the connection to this part also has to be made, physically and technically.

The urban strategy requires the method of partial filling for building-site preparation. At that time this is not very often done. Urban designer Frits Palmboom explains that at that time the partial filling of sites had just started with examples like Tanthof in Delft (by Van den Broek & Bakema) and he is very inspired by the expansion plan of Kethel by Jan Bijhouwer, landscape architect, described in chapter five.[590]

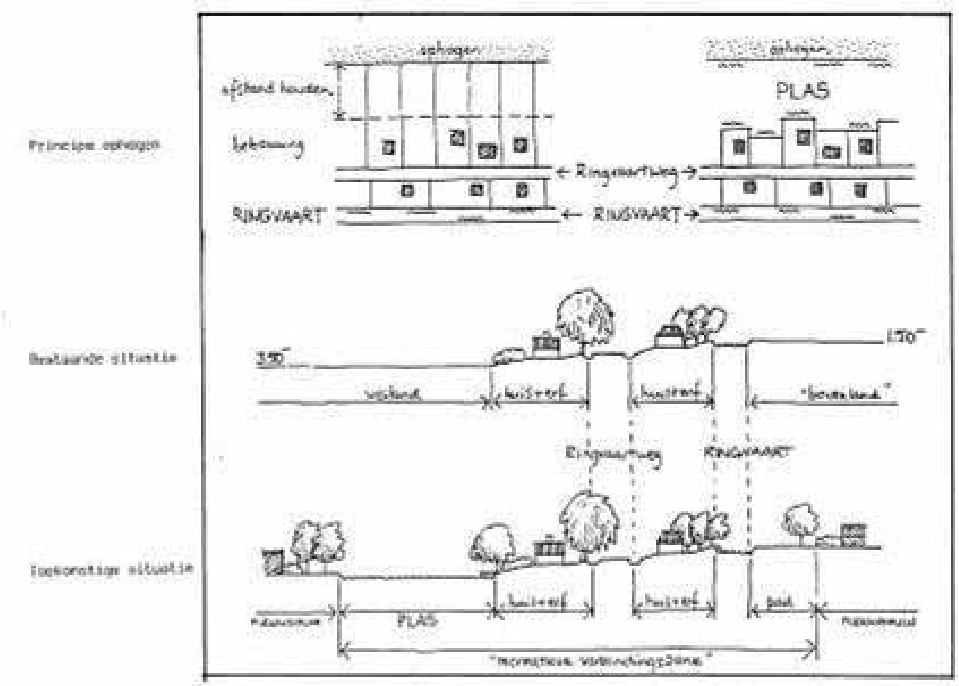
Frits Palmboom starts to work on Prinsenland in 1987 right after his graduation from Delft University of Technology, Department of Architecture and Urban Design. In his graduation project Palmboom emphasizes the relation between city and landscape that is traceable by the marks of history and is not to be handled as a technocratic condition. In 1981 he starts to work as an urban designer at the municipal department in Rotterdam with Joost Schrijnen. In 1984 they make an evaluation report on Prinsenland that, together with Palmbooms' graduation project and other inspiration, forms the basis of his publication *Verstedelijkt landschap* (1987) (Urbanized Landscape). This publication analyses the historical layers of Rotterdam and the visibility of these layers in the urban tissue. It shows the connection between soil, landscape, infrastructure and settlement, just as Bijhouwer promoted in his article about Kethel in 1947.

For Prinsenland other inspirations are the Russian deconstructivists, the Frankfurt *Siedlung* and the Western Garden Cities in Amsterdam. These plans show how different parts can form a unity without centrality. In reaction to the post-war concept of the neighbourhood, Palmboom proposes in the strategy of the urbanized landscape that no central facility needs to be brought into the plan. The plan establishes its merits by hooking onto the existing structures and thus the existing facilities in the surrounding neighbourhoods and the city centre.

[590] Interview by Author with Frits Palmboom on 8 January 2009.



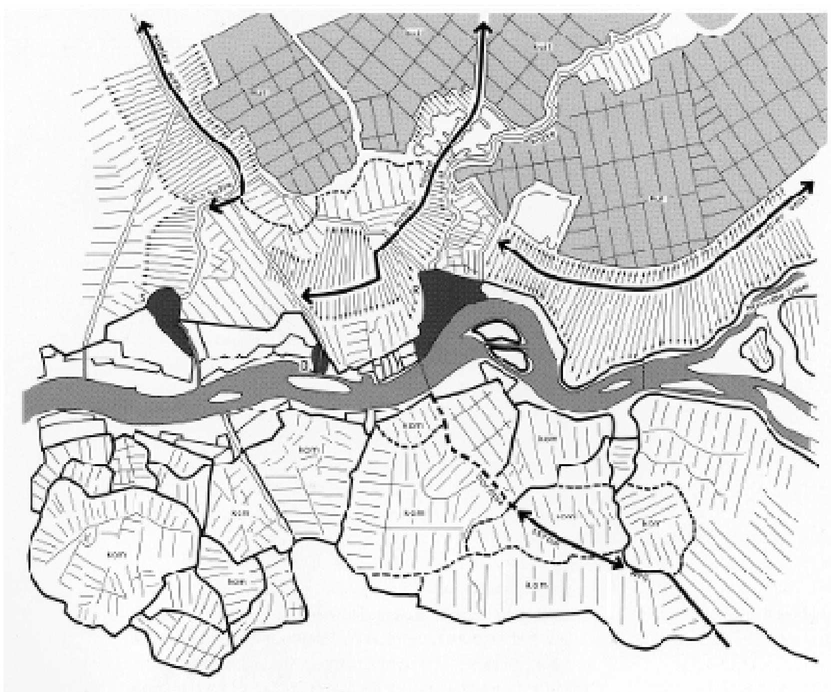
Afb. 13 Inpassing van de Kralingseweg: de "verdubbelde ruggegraat"



Afb. 14 Inpassing van de Ringvaartweg: de plas

Picture 5c.17 Building site preparation as urban design: rules about the dimensions between the original structures and the new development that steer the development.
Source: Palmout Urban Landscapes

Choosing the method of building-site preparation and the way it is applied in the area is done in close relation to the existing landscape characteristics and urban functions. In the higher part the building sites are partially filled in and integral filling is done in the lower-lying drained lake. Where the parts that are filled in with sand border the historical ribbons of houses (which are not developed) the rule is that a distance of two building lots needs to be taken into account. Thus the ribbon also turns outwards, towards the new building areas. The existing lots are protected from pressure and surplus water and a new ribbon of smaller lots come about. Here also small-scale development, housing and small businesses can be situated. This way the method chosen to prepare the sites together with the existing landscape and urban structures, as a part of the strategy of urbanized landscapes, shape the urban design.



Picture 5c.18 Determining landscape structures of Rotterdam that form the conditions for an urbanized landscape.
Source: Palmboom 1987

Urban Construction

Between 1988 and 1995 the building sites in the area are prepared with 1 to 4 m of desalinated sea sand (by truck). To speed up subsidence a vertical drainage system is applied. Between the Kralingseweg and the Ringvaartweg and in Prinsenlandpark lakes are dug and the soil is used for the office site along the Highway A16.[591]

The area has a complex water system with very large differences in water level. The largest difference is between the level of the Ringvaart (2.20 and 2.00 m -NAP), the Ringvaartweg (3.70 m -NAP), the area between the Ringvaartweg en de Kralingseweg (5.20 m -NAP) and the area between Kralingseweg and Lage Land, the area that has so-called free discharge with levels between 5.20 m and 7.00 -NAP. The Middeltocht (6.50 m -NAP) on the east side of the area collects and discharges all the water in the area. The Ringvaart is a *boezem* under control of the Schieland Water Board (currently Schieland and Krimpenerwaard).[592]

The new lake is used in terms of spatial design to provide openness and accentuate the curve in the landscape. In a water-technical sense it provides storage in the calculated 5 to 6 per cent of necessary open water, whilst the norm at that time is 3 per cent. South of the Ringvaart the water level is maintained by digging a new ditch around the new subdivision.

In the area between the Kralingseweg and Ringvaartweg the water system is based on 5.20 m -MSL with a direction north-south and a discharge at the east side in the Middeltocht. North of the Kralingseweg the water levels are maintained as well as possible. The discharge is done in the northern side of the area. To have a sufficient control over the groundwater in the filled in areas, every 300 or 400 m a new ditch is dug in a north-south direction.[593]

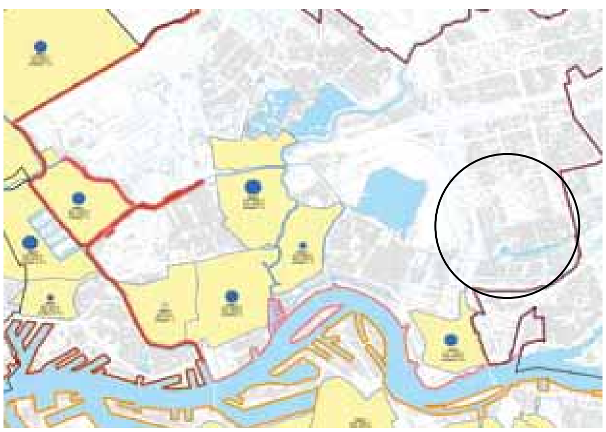
Picture 5c.19 Building-site preparation Ringvaartplas neighbourhood.
Source: Archive Public Works Rotterdam

[591] Anonymous 2002
[592] Stadsontwikkeling Rotterdam 1983, 6
[593] Stadsontwikkeling Rotterdam 1983, 19

Prinsenland in 2011

Due to the strategy of urbanized landscape Prinsenland has become a dynamic and popular urban area. The neighbourhoods 'on the sand' are made out of family homes offering the middle class adequate residences. The ribbons of houses are responsible for the dynamics within the area. The small lot-to-lot scale offers development opportunities for housing and businesses. Small-scale development is possible in the row of lots that is added due to the rule that ensures that the layer of sand layer will not be too close to the existing landscape structures. The existing lots and houses are either well kept and renovated or replaced by new houses. Next to these dynamics the residential areas and especially the lake that is designed to accentuate the larger scale centre structures, offers the overall structure and greater understanding of the area.

As part of the sub-municipality Prins Alexander the water quality in Prinseland will also be improved by the use of nature-friendly banks along the water of the Prinsenlaan.



Picture 5c.22 Prinseland water system is sufficient for the water quantitative issue, but there is a quality issue.
Source: Waterplan 2

The Fine Dutch Tradition: Episode Six

The Club of Rome and the oil crisis offer a stage on which the landscape and ecology regains its importance in the spatial planning of the Netherlands. The consciousness of the impact of the cultural system on the natural system brings back some of the perspective of the natural system. It will still take a few decades, however, before real impact and meaning find their way into changing the perspective more drastically. It is the start of the movement towards sustainability, but what that means exactly and how it should be incorporated in spatial planning is under much discussion and subjected to a number of interpretations over the years. Two spatial results can be subscribed to the impact and meaning: first the development of different methods of building-site preparation that preserve the original landscape in urban developments, and second the importance of surface water.

The urban typology of this episode is characterized by monofunctional neighbourhoods of housing, with both 'cauliflower' and diagonal shapes and amorphous natural water structures all made possible by the method of partial filling of sand or other lightweight methods. The introduction of the landscape within the urban pattern can be considered as a reintroduction to the physical geography.

The strategy of 'urbanized landscape' in Prinsenland makes the connection between the search for identity and the reconnection to the natural system. The relation between the natural system, the landscape, the existing urban structures and the new development (building-site preparation and water structure) becomes very strong. Also there is room in this area for a smaller scale of development: the houses along the ribbons are replaced though the years.

The strategy of 'urbanized landscape' is reminiscent of the characteristics of the Fine Dutch Tradition due to its integration of the original landscape structures with the urban design and available technology. The strategy of the 'urbanized landscape' can be seen as a reinstatement of the Fine Dutch Tradition and at the same time a development of it.

Chapter 6: Adaptive Power (1990 to Today)

Towards a New Balance

The prelude of Accelerating Flower Power generates the transition into the Phase of Adaptive Manipulation. Adaptive and Manipulative are of course contradictory terms, which is why the last Phase is so called – there is no consensus about how to manipulate in an adaptive manner and make the right adjustments spatially in order to be climate-proof. The Manipulative refinement of technology that makes it possible both to maintain the increasingly vulnerable place in the game between water and land, is still present today. Technology that brings refinement in this Phase includes the computer with Internet, mobile technologies and bio-technologies. At the same time there is an adaptive perspective and awareness that high technology causes us to lose sight of what is vulnerable and the necessity to pay more attention to the environment and ecology: the perspective from the natural system.

From the 1990s on this awareness asserts that the Netherlands is like a water machine that needs to be approached spatially as well as technically. Urban designers are very interested in working with the water issue as the basis of their urban design. On the other hand civil engineers need to let go of their strict control and start to adapt to the natural process of the water system.

An important publication at the start of this Phase is *Verstedelijkt Landschap* (Urbanized Landscape) by Frits Palmboom. It marks the change to the Adaptive Manipulative era and it is an urban study, not a historical study, which offers a good framework for the analyses in this thesis.

Palmboom writes about the spatial structure of Rotterdam in relation to urbanism, history and landscape. It is in the world of urbanism that the reaction to the functionalist movement arises after the Second World War. The scientific approach that characterizes this movement spreads new city concepts across the Netherlands, without any consideration for the local historical landscape characteristics of those sites. According to Palmboom these landscapes and cities are considered 'tabula rasa' – clean slates. The strong reaction against this approach again aroused historical awareness and appreciation for original landscape structures and proposed rehabilitation of everything done before the Industrial Revolution, with the emphasis on dwellings.[594]

Palmbooms' investigation, he explains in his foreword, is not historical but into the urban structures of the landscape. In this he includes the underground and the urban intervention as a central theme of his book. He takes Rotterdam because he works there, and because he finds that it is a good case study since the change in urban approach is exemplified there.[595]

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[594] Palmboom 1987, 8
[595] Palmboom 1987, 9

His study explores the spatial history of Rotterdam and he concludes that there are three important layers:

1) Physical geography that expresses the dynamics of the delta.
2) The cultural landscape and occupation patterns.
3) Infrastructure.

These three layers are present in the city structure of Rotterdam, with different manifestations and with each location shaping its specific characteristics.[596]

The first layer is the original landscape, and thereafter the reclamation (with ditches), after which the process of subsidence encourages the system of dikes that are necessary to keep our feet dry. These ensure the occupation patterns on their safe grounds and then there is the start of occupation with the ribbons of houses on these dikes.[597] This is the second layer. In Rotterdam, according to Palmboom, this is a complex layer. Here the reclamations follow the rivers Rotte, Schie and Maas, creating complex patterns in the landscape. Rein Geurtsen and Maurits de Hoog call these complex connections 'breaking zones' or *passtukken*.[598] This complexity is still present today and in his conclusions Palmboom makes a comparison with Amsterdam where the simple landscape system ensures clear interventions.[599]

The third layer is from the twentieth century. Palmboom recognizes the small-scale development undertaken following the landscape structure as a positive and flexible one. The moment that scale increases, a new organizing principle is taken on: the evolution of the mobility network (rail and road). Palmboom identifies two main causes: first the Housing Act of 1901 that compelled municipalities to make expansion plans and gave them the means to expropriate ground; from then on development is no longer done per lot but on a larger scale (Blijdorp). Second is the change in drainage methods, underground drainage systems make it possible to dispense with the original polder allotment and to cover it with a layer of sand. The cities grow along the lines of transport and not according to the characteristics of the territory.[600]

Just like Van der Woud, Palmboom falls back on Fernand Braudel and recognizes old underlying structures in the spatial order that need to be taken into consideration. He makes a plea for the study of the subsoil when making new interventions, for use as a quality guide in the new plan.[601] In that sense his book is an example of the urban analyses that are necessary to understand the city and the influence of the physical geography, the hydrological system, on urbanism also referred to as Landscape Urbanism.

Building further on this and connecting to the issues relating to climate change, perhaps for now the best representative paradigm for this Phase as a 'working paradigm' is vulnerability: the vulnerability of man to natural disasters and the vulnerability of the natural system to human intervention. Vulnerability is often defined as the sensitivity of a system to exposure to

[596] Palmboom 1987, 65
[597] Palmboom 1987, 19
[598] Palmboom 1987, 23
[599] Palmboom 1987, 73
[600] Palmboom 1987, 41
[601] Palmboom 1987, 68

shocks, stresses and disturbances, or the degree to which a system is susceptible to adverse effects,[602] or the degree to which a system or unit is likely to experience harm from perturbations or stress.[603] The vulnerability paradigm is useful because it can establish the rate at which cities need to be protected in balance with what a city could sustain. Men make themselves vulnerable in resisting the natural system, it seems more appropriate to use the perspective of vulnerability in moving with the system. It offers a link between the Manipulative attitude and the move towards the adaptive attitude. This attitude, represented by technological control, can come about when 1) the natural system is incorporated physically and 2) a generalist approach is taken. This will be argued in this chapter.

At the turn of the twentieth to the twenty-first century there is a significant change in society, institutional frameworks and territorial conditions. Society is changing under global and European influences in economic and cultural fields. Institutional frameworks change along economic and political lines. More and more is left to the market and the government takes charge less and less often. Territorial conditions are changing due to climate changes. In 2007 the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in particular alters the view of man's responsibility to nature.[604] The technical approach of the Manipulative Phase has led to the current situation wherein the change of the climate (with an increase in extreme storm water) causes an increased risk of flooding in the polder cities.

This chapter is about the time of the postmodern condition that is regarded as the economic and/or cultural state of society which is said to exist after modernity. Starting in the 1960s of the twentieth century, postmodernist ideas have expanded the importance of critical theory and have been the point of departure for works of literature, architecture and design, as well as being apparent in marketing/business and the interpretation of history, law and culture. A leading American theorist of the postmodern movement, Fredric Jameson, defines it as the dominant cultural logic of late capitalism (the post-war Phase of capitalism). It is roughly equivalent to 'globalization', 'multinational capitalism', or 'consumer capitalism' and sketches the instances of postmodernism as it moves in aesthetics, politics, philosophy and economics.[605] These developments are a revaluation of the entire Western value system and mark the shift from an industrial to a service economy and from a regional to a global scale.

In urban planning this produces the network city, which deals with global competition and the global concerns for the environment and sustainability. Urban designers wrestle with water and continuing in the trend of accelerating flower power it receives increasing attention and new approaches to the water are found. There is an obvious tension between letting go of manipulation, just when all is well under control, and adapting to the changes, because it transpires that the control is not as absolute as thought: climate change demands a new course. Certainly urbanism is

[602] De Graaf 2009, 21 citing White, 1974; IPCC, 2001; Turner et al., 2003; Leurs, 2005
[603] De Graaf 2009, 21 citing Schiller et al., 2001
[604] Intergovernmental Panel on Climate Change 2008
[605] See for this Jameson 1991

reconnecting to the characteristics of the territory and reintroduces physical geography to make a better relation between the urban design, water, soil and subsurface: a more sustainable city. In building-site preparation this means the continuation of partial filling and also the development of new strategies. Water gains a new function of backyard in these plans connecting to public and private space.

Within Brown's cumulative transition states in the development of urban water management in Australia, the type of the Adaptive Manipulative Phase is the water cycle city.[606] This water cycle city is also descriptive for of the Phase of accelerating flower power due to its aim at energy and nutrient cycles and providing waterway protection, fit the quality for the purpose of its intended use and managing the supply. According to Brown et al. (2008) the water cycle city has not yet been implemented as mainstream practice in any city. It is still limited to academic discussions and small-scale demonstration projects.

Since the era is still evolving in the sphere of this tension between the Adaptive and the Manipulative it will be exciting to see what it will lead to and how the Fine Dutch Tradition is transported into the future.

In Rotterdam the cases of Nesselande and Zestienhoven are used to investigate the relation between building-site preparation and the urban design. Nesselande is a good example of how building-site preparation is used to steer urban design. Zestienhoven illustrates a new coalition between urban development and the conditions of the territory and provides good insight into the current relation between the disciplines.

The State of the Disciplines

The worlds of water management engineers and urban designers have one big similarity: the building of their fields of knowledge on other fields of knowledge. The development of building-site preparation shows different fields of knowledge that form a solid base for practical work, but does not lead to the development of an independent field in which new ways of building-site preparation are developed. It seems that in practice each relies largely on knowledge by experience and not much on technical research.[607]

For urban design as a scientific discipline the same situation is apparent – it takes support from different fields: architecture theory, sociology, technology (like soil mechanics and traffic), geography, demography and policy. For example, theoretical writings almost all come from sociologists and architects. The conferences illustrate this phenomenon. In the scientific field of urban design from 2004 seminars on Urbanism & Urbanization are held (in Leuven in 2004, Barcelona 2005, Venice 2006, Delft in 2007 and in Leuven again in 2009) to investigate the specific theory of urban design and its inheritance from the past century. This is very specifically an urban design conference, but urban designers usually go to conferences on architecture and planning conferences on environmental, economic or social issues.

[606] Brown et al. 2008
[607] Biron 2004, 101

Water manager has the same options, specific water management conferences are scarce, and the topic is included in conferences about mud or urban drainage. In 2006 the International Symposium on Lowland Technology (ISLT) organized by the Institute of Lowland Technology (ILT) for engineers in water and mud started sessions about city planning that are open to planning and urban designing disciplines.[608] The same is apparent in the 'genuine engineering' (hardcore engineering) Urban Drainage Conferences organized by IWA/IAHR (Water Association and International Association on Hydraulic Engineering and Research) and the Joint Committee on Urban Drainage (JCUD) from the 1970s.[609] In 2008 two out of 12 sessions are about the urban context, involving about 50 out of 450 people attending the conference. This started ten years ago and the percentage increases at every conference.

The first conference organized by urban designers and water managers together is the 'Urban Water Conference', hosted by Leuven University. It intends to bridge the gap between the disciplines of water management, ecology and the approaches of engineering, urban design and spatial planning. In the longer term this has to lead to new paradigms in managing water in the urban environment. In the preface to the proceedings the organizers write:

> The role of education in the coming generations of architects and engineers in improving urban environments needs also to be recognized. At present, most universities focus on teaching conventional techniques without giving enough space for discussing other options between disciplines.[610]

The Department of Earth and Environmental Sciences and the Department of Architecture of Leuven University organized this conference to bring their worlds together. Both departments have invited their associates to the conference trying to obtain a mix of participants. In practice this turns out to be easier said than done. The two groups, due to their different sessions, remain rather detached. In the urban design sessions (urbanity and hydrology) a lot of attention is paid to the cultural aspects of water, and the greater system of sea and river, the regional system of ground and storm water in the polder and drinking water in developed and developing countries. The engineering sessions (mitigating natural disasters, rethinking water governance) are for the most part dedicated to modelling and testing different technologies, for example in improving water quality, treating waste water and calculating risks.

Only one session brings about some overlap between the two groups: urban water management, where more physical solutions for flooding are discussed. Although a good start has been made it will take years to develop a common field in which both disciplines can meet.

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[608] See Proceedings 11th International Conference on Urban Drainage, Edinburgh, Scotland, UK.
[609] 11th International Conference on Urban Drainage, 11ICUD, to be held at the Edinburgh International Conference Centre, Edinburgh, Scotland in the week 31st of August to the 5th of September 2008
[610] Feyen et al. 2009, XIV

Designers and Water Board People

In order to stimulate a better understanding between the disciplines at the University of Technology in Delft the collaboration between the departments of urbanism, civil engineering, policy and water management increases. It is difficult to have students working together due to administrative and organizational matters but the cooperation that is experienced is very useful and successful. The association between urban designers and engineers at the study stage results in a better relationship in their subsequent working lives.

One example is Pieter van Berkum's Master's thesis in civil engineering: *Ruimte en de kunst van het waterbeheer, Een onderzoek naar verbetering van het ontwerpproces van het stedelijke waterbeheer* (2007, Space and art of water management, a research into the improvement of the design process of urban water management). His starting point is the thought that technical knowledge will benefit fully if it connects to the practice of planning and design of space. Van Berkum acknowledges the assumption that theoretical knowledge is enough to conquer the water challenge and he is interested in how this knowledge can be used during the process of urban design in order to make a qualitatively good and waterproof design. Van Berkum interviews urban and landscape designers to find out when and how water technology can be integrated into their design process.[611] On the other hand, he interviews the engineers of the Water Boards to find out how they deal with new urban developments that alter their water systems. The Water Boards maintain the water system and offer the conditions in which new developments can take place. In that sense the urban and landscape designer and the Water Boards represent the embodiment of the choices and deals that are made between water and city. The relation between water and city is characterized by a mathematical deal (engineering) and a spatial expression of this (urban design), Van Berkum considers it an art to bring these two together.[612]

Most designers think they know how the water system works but have no specific knowledge of hydrology and the modelling of water systems. Calculations and analyses are done by engineering consultants who offer the details and sometimes improvements for the design (when the advice comes at a later stage) and sometimes it is an iterative process.

Most urban and landscape designers when interviewed see the water issue as a burden and an opportunity. The water system is non-negotiable and will have to be taken into account; its conditions will have an influence on the design of Dutch cities. In that regard, the interviewees believe that water is not yet where it should be on the urban agenda.

> The water is essential to the Dutch landscape; it shaped the Netherlands and gives identity and culture to the landscape. The moment the water system alters spatial planning new possibilities appear not only for the

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[611] Charlotte Buys Dienst Ruimtelijke Ordening Amsterdam, Annemieke Fontein Dienst Stedenbouw en Volkshuisvesting Rotterdam, Eric Luiten Landschapsarchitect BNT/TU Delft, Yttje Feddes Feddes l Olthof, JanDirk Hoekstra H+N+S Landschapsarchitecten, Roy Bijhouwer Atelier Quadrat, Robbert de Koning Bureau Robbert de Koning, Mariette Claringbould TLU Landschapsarchitecten, Jago van Bergen Van Bergen Kolpa Architecten, Florian Boer VHP, and Edzo Bindels West8.

[612] Van Berkum 2007, 106

> water system but also on life and use of the territory. It is inspiring and challenging to work with technical and natural conditions for the design of new living environments. (Robbert de Koning)[613]

The interviews with the urban and landscape designers and the water board people bring to light three problems in the application of water technology in urban designs: 1) limited possibilities for a juridical way to integrate storage and discharge into spatial planning; 2) doubts about alternative solutions for storage and discharge and doubts about the effects of the disconnection of rainwater from the sewer system on water quality; and 3) lack of a model or an instrument that makes it possible for urban designers and Water Boards to combine local conditions in the urban design, to design and test the spatial water system.

The limited possibilities of finding a juridical way to integrate storage and discharge into spatial planning refer only the Watertoets (Water Test). This is an important instrument requiring urban developers and Water Boards to work together to design a sustainable water system for new or restructured areas. In this way the Water Boards are committed to the new expansions from an early stage. At the moment the designers feel that the instrument does not work as it should. It is landscape architect Charlotte Buys's experience that the water board is not always aware of the exact conditions necessary for the water system in urban areas. That is why they use simple rules, like 10 per cent surface water to compensate for the paved surface, which are then applied to each new development, creating a fragmented approach to the water system that should be dealt with at a higher scale level. That is why a water foundation was set up in Rotterdam; the developer of a small area can buy off the water assignment for that area by payment to the water foundation, which uses the money to solve the problem at a higher scale level.[614]

Rules used by Water Boards are derived from their experience in agricultural areas and are not always as easy to apply in cities. The rule of 10 per cent surface water is sometimes very difficult to fit into urban areas with high densities. Another difficulty is that the surface water rule is stated in square metres, while the aim of the water board is to store cubic metres of water. By stating the amount of cubic metres in the water rule, urban and landscape designers will have more freedom to solve this in different and alternative ways and will be more inspired to create new designs. The designers, however, do not actually have enough technical knowledge to support their choices, which means that Water Boards cannot simply trust the alternative solutions.[615]

The exchange between the disciplines should remove the doubts about alternative solutions for storage and discharge and the lack of confidence about the qualitative effects of the disconnection of rainwater from the sewer system. Uncertainty plays an important role in the appliance of new technology in urban water management. The art of a good urban design is not to reduce these uncertainties, but to find the best route between

[613] Van Berkum 2007, 30
[614] Van Berkum 2007, 31
[615] Van Berkum 2007, 32

recklessness and conservatism: the brave attitude.[616] This insecurity is also one of the obstacles to both disciplines working on the same projects, because engineers tend to take the conservative attitude and designers the reckless one.[617]

Climate change places Water Boards in a new role, that of developer instead of maintainer. This new role also demands a flexible attitude, which does not come naturally to the water board engineers. When encountering urban and landscape designers who think outside the box, outside the systems and come up with unlikely solutions, the engineers keep their guards up high, making cooperation difficult. To develop a new typology for urban water, cooperation is necessary and knowledge about each other's instruments crucial. There is a need for a common language used by both disciplines. The best city designs, as we can learn from history, are the ones that combine technology and urban design.[618]

Van Berkum designed an instrument that can help urban designers use water management principles in their design, while at the same time the water board is able to control the instrument. It offers insight into the different possibilities (discharge, storage and infiltration) in spatial measures (open water, *wadi*, building) and calculates if together they deal sufficiently with the water issues on hand. This way water management and the design of cities can be better attuned to one another.

Urban Developments

In this Phase two more or less contradictory developments in national planning occur. On the one hand the national concern for water issues increases, but on the other the involvement of the national government with the spatial order drops off and more freedom is given to private development and the municipalities.[619] In fact it is a return to the situation in the nineteenth century, when water also became of national concern and (in this case) the municipality set out some basic rules and the private developers worked out the details. This liberal and de-central course is under great criticism because, assumedly, it leads to spatial disorder.

One of the reports that reflect the development of liberal spatial order, and the first national report to help in the rediscovery of water as an element of urban development, is the *Vierde Nota Extra* (VINEX, Fourth Report Extra, 1991), which addresses the expansion of towns concerning living, working and recreation. One million houses are planned by 2005; a number that is later readjusted to 600,000.[620]

Two other national reports are important to this study, because they reflect the attention being paid to water issues: *Nota Belvedère* (1999) and *Anders omgaan met water, waterbeleid in de 21e eeuw in de stad* (2000) (Another way of dealing with water, water policy of the 21st century). These two form the main foundation on which developments take place from the start of the twenty-first century. The increasing importance of history and

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616 Geldof 1997, 265-269
617 Van Berkum 2007, 98
618 Van Berkum 2007, 38
619 Meyer 2008, 12-13
620 Ministerie VROM, 1991

the water assignment together culminate in the restoration of historical water structures in cities. These historical water structures are considered stimulating for the local economy and form a qualitative asset for the working and living environment. Some contribution can also be made to the water assignment, but that is not the case in examples like Breda and Utrecht, where city revitalization is the key motivation. In Breda the old harbour is reconstructed and in Utrecht a *singel* is reinstated to restore the logic of the urban structure of the inner city.

The effects are visible in the reports that follow. In 2008 four reports dealing with planning appeared almost at the same time: *Samen werken met water* (Working together with water), *Randstad 2040*, *Een Cultuur van Ontwerpen* (Culture of Design) and a plan from the Ministry of Traffic and Water to improve the railway network.[621] Two of these plans consider water, *Samen werken met water* is very specific because it advises about water safety and *Randstad 2040* sees water as a guiding principle for the development of the Randstad. *Een Cultuur van ontwerpen* is important for the discipline of urban design because here it is considered to be the discipline with the capacity to integrate the difficult spatial assignments with which the Netherlands has to cope.

Another report that influenced attitudes to a connection with the natural system is: *Bouwstenen Leidraad Grondwaterbescherming* (Components for a guidance document on groundwater protection). For improved protection of the groundwater quality, the focus of the policy should be more on local conditions, such as subsoil and groundwater. To enhance this focus the *Rijksinstituut voor Volksgezondheid en Milieu* (RIVM, National Insititute for Public Health and Environment) proposes a generic framework for a groundwater protection policy - to be kept in an area dossier - that can be expanded for each site. This dossier contains all relevant information on what measures can be developed to achieve the desired effects. In an effort to achieve more uniformity and effectiveness in the Dutch groundwater protection policy, the former Ministry of Housing, Spatial Planning and the Environment (VROM) plans to develop a guidance document on groundwater protection.[622]

This groundwater protection policy also impacts the discipline of landscape architecture, which works with the natural system. Following the maturation of the landscape architectural discipline in the 1970s, a trend emerges of the landscape architects gradually taking over the field of urban design. Apparently their knowledge of the landscape and ecology gives them an advantage in the development of urban designs. Offices like H+N+S Landscape Architects and West 8 Landscape Architects produce plans that respond to the challenges at hand and the main focus of this era: sustainability.

Urban design is done on a city scale. On a higher scale planners 'design' the conditions for the new city type: the network city. The Randstad, an urban conglomeration considered as metropolis, competes with other European and world cities. Economic conditions and living environment can be improved with good infrastructure, good housing and plenty of jobs.

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621 Meyer 2008, 12-13

622 Wuijts et al 2007

As a part of the environmental issue, water is introduced in the VINEX projects as a leading principle. In the locations Leidsche Rijn in Utrecht, Ypenburg in The Hague, Vathorst in Amersfoort and Nesselande in Rotterdam, water is used as an important structuring element.

Leidsche Rijn in Utrecht is an example of the changing strategy from rapid discharge to one of first holding, then storing and only then discharging excess water (the three-step strategy of the 21st Century Water Management Committee).[623] The water issue of 'hold and store' is often possible by means of infiltration and is achieved in the urban design by constructing ground level or underground infiltration devices. An example is the vegetated filter swale or *wadi*, which is a green trench that fills up in a rainstorm and then allows the water to gradually filter into the groundwater. In Leidsche Rijn the swales or *wadis* are part of the green structure, and with careful design they occupy no additional space.[624]

Laak, as a part of the VINEX site Vathorst (Amersfoort), has the Laak River as a main structuring element. Due to the high density realized here the water needs to function as public space and for recreation, just as in the old Dutch water towns. As preparation for the urban design West 8 landscape architects and urban designers closely studied the typology of canal cities like Delft, Dordrecht and Amersfoort. The result is that water, road and buildings form the main structure of the neighbourhood in one unity and that the detailing of the public space and the water structure has a high priority.

An important starting point is the balance between land and water in building-site preparation. Soil extracted from the watercourses is used to fill in the building lots and streets. This is called a closed soil balance and makes a flexible water level possible, as in the Amsterdam *Grachtengordel*. Considering these features are part of the Fine Dutch Tradition, Laak is a modern example.

The water system of the VINEX expansion of The Hague, Ypenburg, is designed perpendicularly to the sand ridges that form the landscape along the coast of South Holland. The green structure and the water system form the main carriers of the urban design and are expected to make a better environment. Ypenburg, designed bij Palmbout Urban Landscapes, emerges as a picture book of the possibilities of combining building typology with water course typology. The differently characterized *singels* offer different combinations. For example a former landing strip is now a water strip showing the largest part of the neighbourhood and forming a formal water course along both sides of which larger blocks are built. Other water courses form backyards and in the water neighbourhood the houses are built in the water.[625]

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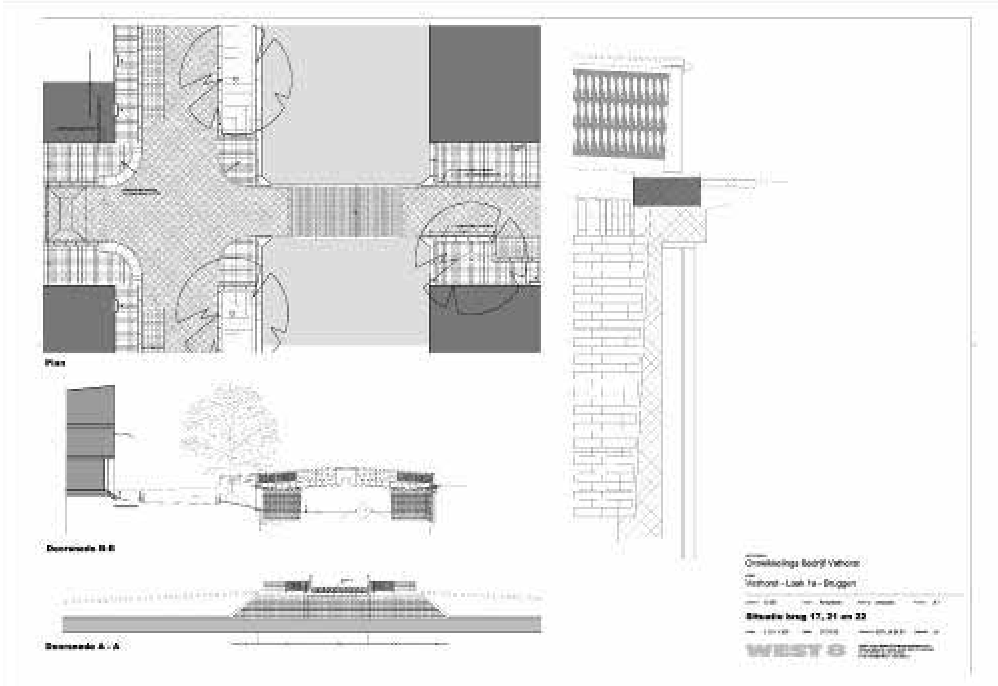
[623] Adviescommissie Waterbeheer 2001
[624] Tjallingii 2007, 87
[625] Office documentation Palmboom & van den Bout



Picture 6.1 Detailing of the quays and bridges in Laak.
Source: West 8

Picture 6.2 New houses in Laak with a historical connotation.
Source: West 8

Rieteiland and De Bras, parts of Ypenburg, are integrally filled in (1999-2000) with the IFCO-method (*Intensief Forceren Consolidate Ondergrond*, Intensive Forced Consolidation of Grounds) to accelerate subsidence and therefore enable an earlier building start.[626] In garden city De Bras, 325 m^3 of water storage per hectare is applied and the main urban structure follows the lines of the original landscape structure.

The Rotterdam case, Nesselande, is described further in this chapter and shows how the water produces differentiated urban designs and also how building-site preparation can be used as an urban design component. One important element of the urban development in Nesselande is the public awareness, enforced by regulations, of the adverse influence on the environment caused by the use of some chemicals and building and garden materials.

Picture 6.3 *Boezem* and polder waters: integrated in De Bras, Ypenburg.
Source: Sybrand Tjallingii

Design with Water

Since 2005 the state has stimulated water projects. The Ministry of Transport, Public Works and Water (V&W), the Ministry of Agriculture, Nature and Food Quality (L&V), the Ministry of Housing, Spatial Planning and Environment (VROM) and the Ministry of Education, Culture and Science (OCW) start the programme Design with Water to ensure the spatial quality of the national, regional and local projects in preventing water nuisance. The government sponsors pilot projects along the coast, rivers and in the regional and urban water systems. The action is one of the 29 projects from the programme *Actieprogramma Ruimte en Cultuur* (ARC) 2005-2008 (Space and Culture) that aims at improving the spatial quality of the Netherlands by:

[626] www.ifcomethode.nl checked on May 12, 2009

- Calling attention to the cultural meaning of the water assignment;
- Improving the influence of urban design;
- Ensuring spatial quality in the planning process of explorations, actual plans and project decisions for national, regional and local projects with a water issue.

The programme first publishes five introductory essays and organizes a roundtable discussion to set the course of the programme and start the pilot projects.[627] The interesting thing about the programme is that knowledge is developed and shared within and between the pilot projects to make the practitioners of urban development more aware of the possibilities and difficulties. The pilot projects have a wide range of assignment types and are geographically distributed over the Netherlands in three groups: coast, river and regional and urban water systems. The latter, considering the challenges in the polder are:

1. *Pilot Amsterdam Zuidoost Lob*: What can be learned from the governmental and planning instruments? What is the meaning of research by design in this regard? The pilot is aimed at the maintenance, protection and development of green structures in a post-war area; the integration of water, housing, recreation and infrastructure over land and water; and long term planning.
2. *Pilot Venster Bodegraven-Woerden*: How can design contribute to the (re)definition of choices for integral development? This pilot shows that to initiate is not enough, realization is as important and the corporation and budget are crucial in this.
3. *Water centraal in gebiedsontwikkeling* (Water central in district development): consider the Zuidelijke Randmeren and Rode Waterparel from the viewpoint of water quality and spatial development. How can a dynamic water management system be used to achieve urban quality?
4. *Ontwerp Voorop* (1)! (Design First!): What are the experiences and the role of urban design in the different Phases of district development, and what is necessary to maintain quality and goals from exploration to realization?
5. *Pilot Plantage Rotterdam* (Zuid): test simultaneous calculating (budgeting) and designing of the reconstruction of a post-war area with the introduction of large water surfaces.
6. *Pilot Westflank Haarlemmermeer:* an integral approach towards district development with water.
7. *Restructuring Tiel Oost*: What possibilities does Tiel Oost have for a combined intervention of restructuring inside and building outside the dike on a superlevee?
8. Water robust building, The Leven met Water project, (Living with Water Project): integrate water management information in the urban design.[628]

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[627] See Anonymous (2007b)
[628] Conference *Ruimtelijk ontwerpen met water* (Satial design aith water) March 12/2009 Rotterdam

These projects are all based on learning by doing, trying to spread knowledge and experience in organizations, to improve procedures and be able to built new sustainable water cities. One aspect of this, as described above, is the relationship between the disciplines that together have to design this new hydrological city.

Water Awareness

The slow recognition of water as an important element of a sustainable city that started in the 1970s is grounded in the Institute Deltares, the research institute and specialist consultancy for matters relating to water, soil and the subsurface. In 2005, the Dutch government decided to bring together in a single institute for applied research and development – Deltares – different existing centres of excellence (Geodelft, WL | Delft Hydraulics, parts of TNO building and subsurface, and specialist services of Rijkswaterstaat, the executive branch of the Ministry of Traffic and Public Works). The Institute develops, applies and shares knowledge about water and subsurface issues in a new, integrated way in responce to increasing pressure on habitable space in deltas, river basins and coastal areas caused by economic activity, rising populations, falling land levels and the impact of climate change all over the world. Deltares aims at applying relevant knowledge in an integrated way while taking more perspectives into account, such as technology, natural systems, policy, juristic and economic perspectives in order to achieve a sustainable shaping of the living environment, using high-grade technological solutions that have the support of society in general.[629]

In December 2009 the urban water management department of Deltares wrote *Land & Water Management in the Urban Environment*, in which the concept of the water city is introduced. Here the water is set at the heart of the city, making it more sustainable and less parasitic, that is less dependent on external resources and less waste-producing, thereby reducing the ecological footprint of the urban area. This can be done by reducing inputs of water, food and energy; imports of sand, ground and building material; and recycling water. The water should be more multifunctional in providing space, providing energy and food, and supporting the soil.[630]

Even before climate change became a fact water managers were aware of the adaptations to the hydrological system that are necessary to live with the water safely and pleasantly. To enhance the capacity to 'make' this a driving force to the knowledge, infrastructure was done with the funding of the programme *Leven met Water* (Living with Water) in 2004. Three aims are defined: 1) giving water new space; 2) intensification between the beta and gamma sciences; and 3) enforcement of information infrastructure between the stakeholders.

When the programme is concluded in 2010 the first aim is realised in the creation of more water storage and a more resilient soil water system in several projects. Since the start of the programme a natural interaction has been established with the issues of area development and climate change. The water challenges are more attainable when connected to other objectives, such as the regeneration of areas. Water as a steering principle is

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[629] http://www.deltares.nl/en/about-deltares checked April 12th 2011
[630] Deltares 2009, 12

on the agenda and a crucial means in developing adaptation strategies for climate-proof cities.

Also, the second aim of achieving better interaction between the beta and gamma sciences is successfully accomplished. In many projects both sides are represented and one of the results is the adaptation ladder, making small connecting steps in investing in climate-robust development.

Finally, the third aim to build better knowledge infrastructure is usefully reached by making the water domain part of larger knowledge structures and also part of the awareness in policy, economics and people.[631]

Building-Site Preparation

It is beyond this project to go deeper into the separate fields of engine power, general water management, soil mechanics, soil improvement, hydrogeology, pile foundations and drain systems in the Adaptive Manipulation Phase. First because the point of these fields has been made in the former chapters and second because the change of attitude is recognizable – not from the viewpoint of these separate fields, but from the integrated field of building-site preparation. The methods of building-site preparation are the same, but different aspects are under development and some new developments take place. There is a lot of interest in floating housing and, especially in the river areas, building flood-resilient houses outside the dikes in flood-prone areas is investigated.

In addition, newer sewer concepts are explored such as a concept developed by TauwMabeg together with WAVIN KLS, the Smart Drain®, which is based on a sewer system and the local collection and discharge of rainwater directly onto local surface water.[632]

Building without a crawlspace is also a solution for high groundwater levels. A crawlspace used to be necessary for ventilation of the wooden floors, but if concrete is used to construct floors, crawlspaces are no longer a necessity. Because of the drainage policy that aims to keep crawlspaces dry, there is also a drought problem. To prevent water nuisances the groundwater level should be 30 cm below the bottom of the crawlspace. On the other hand, the use of wooden foundation piles requires the groundwater level to be high enough to keep them under water to prevent rotting. This demands a precise regulation of the groundwater table. Building without crawlspaces will effect a reduction in the costs of building-site preparation, foundations and floor construction.[633]

It is to be expected that the improvements in different fields will, in the end, together lead to changes in practice. But real innovation in building-site preparation, between technical and spatial design, is dependent on cooperation. In the following paragraphs initiatives are described that try to improve this relationship from both sides: from the spatial design and the technical side.

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[631] Satijn et al 2010, 1-4
[632] TauwMabeg 1996, 19
[633] TauwMabeg 1996, 19

Operating Bottom-Up Technically

At the beginning of the 1970s a working group called *Bodem en Planologie* (Soil and planning) is brought together to study how soil research and geological fieldwork can contribute to urban development; how aspects like soil and water can be more systemically involved in urban plans and designs.[634] Segeren and Hengeveld in their 'bible' (metaphorically speaking, since there is no other book) on building-site preparation see the relation between making use of the soil conditions and the water system on the one hand and living quality on the other as difficult to determine. How can quality be established from different methods of building-site preparation and how can the starting situation play a role in the urban design?

> It is doubtful that in a dense urban area something like the original polder structure and land roads with trees can play a part in the quality of the urban design. The vertical elements, the buildings, will probably overshadow these structures. For the use of the soil, water and natural elements, space is needed. If, like the Urbanization Report proposes, cities are going to be built more compactly, then the possibilities of playing with the programme, soil conditions and environmental qualities will be restricted by the boundaries of the city and its density. However, lately projects have been carried out in which natural and cultural conditions are incorporated into the urban design and an evaluation of the living quality is required. For these projects the studies into soil conditions and the water system, necessary to decide which method of building-site preparation to implement, are rather limited. Also the coherence between aspects of civil engineering and between civil engineering aspects and urban design are only partly developed.[635]

In 2004 Biron investigates whether things have drastically changed since the time of Segeren and Hengeveld and whether there is reason to be more optimistic after all these years. His investigation is his graduation project at Delft University of Technology, Faculty of Civil Engineering and Geotechnics. The title of his thesis: *Beter bouw- en woonrijp maken: een verkennend onderzoek naar het bouw- en woonrijp maken in de Nederlandse praktijk en de problematiek rondom wateroverlast op de bouwplaats* (Better building-site preparation: an investigation into the practice of building-site preparation and the problems of water nuisance on the building-site).

For his investigation he takes the report by Van Dijk (and Hengeveld) of 1977 *Onderzoek naar de wijze van bouwrijp maken van terreinen in een twaalftal gemeenten in Nederland* (Research into methods of building-site preparation in twelve municipalities in the Netherlands), described in chapter 5c, and like that report he studies 12 cases to see what the state of the art is in the practice of building-site preparation.[636] He concludes that the quality of building sites has degraded badly due to the design criteria,

[634] Westerveld et al 1973, 47- 65
[635] Segeren and Hengeveld 1984, 36-37
[636] Van Dijk et al. 1977

incorrect data and the fact that there is confusion about the responsibility of the municipalities. He recommends making an up-to-date version of Segeren and Hengeveld's 'bible' to improve the knowledge of the participants in building-site preparation.[637]

All the projects that Biron studied are in polders with bad soil conditions, neither worse nor better than in 1977. The percentage of surface water in urban development increases over the years see table 6.1. None of the 1977 projects has more than 9 per cent surface water and only one project in 2004. Fewer than 3 per cent surface water in the urban area is almost the same for both years.[638] The surface water in all of the 2004 cases offers beautification of the urban environment, drainage and water storage.

Table 6.1 Percentage of surface water in urban development in 1977 and 2004

	> 9 %	6-9 %	3-6%	<3%
1977	0	25%	58%	22%
2004	1	45%	28%	26%

Biron does not see any influence by the water board in situating the surface water or any motivation for the taken starting points in constructing the water system. This is not mentioned in the research of 1977, neither is the issue of water quality, which is very important in all the projects in 2004, nor the disconnection of the paved surfaces from the sewer and the application of black earth on the sites.[639]

The approach towards building-site preparation in 2004 still very much relies on knowledge by experience and not much on technical research. Sometimes for small sites all the investigations are made, while large areas are developed on half investigations and assumptions. This is a reason for things going wrong and Biron finds this worrying.[640]

Biron's thesis has led to the project *Beter Bouwen Beter Wonen* (Better Building Better Living formerly known as Better Building-Site Preparation) that the consortium of Delft University of Technology, SBR, Sterk Consulting, Witteveen+Bos, Grontmij and GeoDelft starts in 2006 to improve the development of knowledge and the development processes. The incentives are the expensive problems concerning floodwater nuisance, groundwater issues, subsidence, management and maintenance during later Phases. The projects seek to order and enclose 'state-of-the-art' theoretical and practical knowledge for all the stakeholders. The intention is to develop new technology based on new approaches to the process, financial, organizational and policy aspects.[641]

These investigations and projects are in the sphere of water managers while the geosciences also need to improve the basic way of working to make advances in building-site preparation. This is done in the knowledge programme of *Stichting Kennisontwikkeling en -overdracht Bodem* (Foundation of Knowledge Development and Distribution Soil). The

[637] Biron 2004, 6
[638] Biron 2004, 73
[639] Biron 2004, 86-90
[640] Biron 2004, 101
[641] www.bouwrijp.nl checked on 19 juli 2010

foundation stimulates projects that develop knowledge about soil conditions in relation to subjects such as energy, ecosystems, water and spatial development. In these projects methods, instruments and processes are designed to be able to assess the natural conditions of the soil and have the technical potential of obtaining information on spatial matters. An example is the project Bodem4gebieden where different tools are developed and applied to enable early collaboration between city developers and soil engineers. For this purpose a wiki (interactive website) is developed where all these tools can be found.[642] These methods and tools vary from collecting soil information to functions within the urban development dealing with regulation of the underground in relation to conditions above ground.

These programmes and projects show a change in the approach to the underground in urban designs. Previously the first priority had been infrastructure and fitting in the landscape; now the soil conditions are included in the Phase of spatial planning and are not only part of a later Phase of realization.[643]

Operating Bottom-Up Spatially

From the quotation in the former paragraph it is obvious that Segeren and Hengeveld are still very sceptical in 1984. But, just a few years later the first projects making successful combinations occur, like Prinsenland and Beverwaard in Rotterdam, the first with its urbanization strategy and the second with the use of the polder structure.
Another much older example from the 1980s is the De Haagse Beemden in Breda.[644] Here the interaction between ecology and urban design is the guiding principle in aiming to make a fluent transition from city to surrounding landscape connecting to the main ecological structure. First geohydrology, soil conditions, ground floor levels, water system, natural values and the possibility of connecting to the existing sewer are investigated. This information is used as the foundation of the urban design and the water management plan.[645] Then a structure of water courses is set out along which the different environments are situated: wood, nature, landscape, park or canal. The watercourse in each sphere has different detailing in the width of the water, the slope gradient, bank landscaping and the type of plants used.[646] The district is rather low lying so the building-site preparation takes up a large part of the development budget. The residential areas are filled in with sand from the lakes nearby. In this case building-site preparation is a very important aspect, perhaps the most important, in dealing with the underground. [647]

For the spatial world another new method of approaching order in space is the *lagenbenadering* (Layer Approach), stimulated by the national memorandum Fifth Report of Spatial Planning (*Vijfde Nota Ruimtelijke Ordening*) in 2000. The Layer Approach is developed by Hoog, Sijmons and

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642 http://b4gwiki.wiki.xs4all.nl checked on 19 juli 2010
643 Van den Berg and van der Eijk 2008
644 Structuurgroep Haagse Beemden 1975
645 TauwMabeg 1996, 38
646 Segeren Hengeveld 1984, 230
647 Segeren and Hengeveld 1984, 237

Verschuuren as a conceptual framework to guide Dutch spatial policy.[648] The original approach distinguishes three types of connected layers characterized by different rates and types of (potential) spatial development and change. The lowest and slowest layer is represented by the subsoil layer (soil, water, nature, landscape), which consists of longstanding structures that are difficult to change. The middle layer corresponds to the network layer (infrastructure), which represents large-scale civil structures that can be changed but at a slow rate and often involving high costs. The upper and fastest layer is the occupation layer (living and working), which represents the (use of) buildings with a relatively high rate of change.[649]

The most important advantage of the Layer Approach is the aspect of time it introduces. To reduce the timescale of underground processes in spatial planning and maintenance, negative effects of planning the 'flat' surface can be prevented in the short term, for example, in high maintenance costs, water nuisance, loss of landscape identity, subsidence under streets and houses, soil pollution and leaking building pits. Also, the potential of the underground for social themes such as sustainable energy production, agriculture, water management and climate change can be part of spatial planning. The Layer Approach is a tool for looking into the alternatives and considering the effects of interventions in the short and long term.[650]

The Layer Approach has been heavily criticized in recent years for paying insufficient attention to the relationship between the layers and for the layers failing to represent the complex character of functions and use. Additionally, the dynamics of the layers are not as simple as the approach suggests. Van Schaik (2007) proposes four areas of improvement: (1) potential individual activity patterns; (2) functional spatial networks that represent flows of people, goods and information; (3) space as relational spatial elements; and (4) physical networks that are made up of physical nodes and connections.

However, in practice it has become a method of approach that is preferable to no method at all. Within different domains and projects more precise expansions of the layers are made. For example from an urban design viewpoint, Heeling, Meyer & Westrik (2002) use the following layers: territory/substratum, ground plan, public space, buildings and usage for their investigation into the foundations of urban design. This is a refinement in types of space and dynamics and forms a good counterbalance to the approach of Hoog et al. The ground plan is formed by open and built space so the infrastructure is therefore better represented when taking infrastructure, public space and buildings as organizing principles. Another combination is made by Döpp, Hooimeijer and Maas (2010), who in addition to public space, also introduce metabolism and users. Their six-layer approach results in the desired refinement in urban typology and responds to most of Van Schaik's suggestions. The metabolism layer represents flows of goods, energy, air, products, waste and water: the processes that allow organisms to grow, reproduce and maintain their structures and respond to

[648] Hoog, Sijmons en Verschuuren 1998
[649] dRO Amsterdam 1996; Hoog, Sijmons en Verschuuren 1998
[650] Anonymous 2001

their environments.

Another important way of taking it bottom up is the GeoCheck by Deltares. It offers the possibility of taking into account the quality of the soil conditions and the groundwater at an early stage. It makes it possible to speed up the building process, save on costs due to well balanced decisions and thus make a qualitatively better environment. GeoCheck supports policymakers, builders, designers and project developers in making the most of urban designs in which the soil conditions are taken into account. The subjects that are checked with GeoCheck are building on weak soils, decontamination of soils, soil research for controlling risks, horizontal steered drilling, climate-proof planning, leak management and underground parking.[651] To make the step from these subjects to the urban design a 'translation' of this technical data to the spatial design - and visa versa the implications of the urban design on these subjects - is necessary.

Rotterdam Nesselande

Nesselande in Rotterdam uses water structures as a qualitative carrier of the urban plan.[652] It is the next logical step in the expansion of Rotterdam in an easterly direction that started after the Second World War. The new expansion of 4,800 houses is partly situated in the Alexanderpolder and partly in the Eendrachtspolder. The starting points are the use of sustainable materials, application of the city heating system, and support for solar energy. The water quality is maintained by storing the water in the ground (infiltrations and *wadis*) and the open water system; the area has a closed water system with its own circulation. The sewer system is a separate system and by making 50 per cent of all shores nature-friendly banks, the water quality in Nesselande is very good.

The main structure of the area follows the flow of the water. The long park that goes from the northeast to the southwest is an integral part of the whole expansion, touching and connecting the three urban environments. It contains a water course that transports the water from south to north; the water returns through the garden city. This park is also part of an ecological barrier to connect the green structures in the south with the polders in the north. The park remains on the same ground level and the water structure is dug out to form different islands.

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[651] http://www.deltares.nl/nl/product/151715/geocheck/187445 checked on April 5th 2011

[652] The information in this paragraph comes from an interview by the Author with Francois Konings, urban designer and project leader of Nesselande with the Department of Urban Design of the Municipality of Rotterdam (dS+V) on January 20th 2009.

Picture 6.4 Master Plan for Nesselande (by dS+V) with at the top right the water town, along the diagonal the garden town, and on the water side the coast town.
Source: Municipal Rotterdam

The water system is disconnected from the lake but is the connecting element of the three different urban environments – Coast City, Garden City and Water City – that make up Nesselande. To be able to control the quality of the water this is the best solution and another spatial effect is that it can play a different role for each type of urban environment.

Coast City is situated at the Zevenhuizenplas, an artificial lake from which the sand for filling the building sites is taken, see chapter 5b and 5c. The lake is dug in the 1960s to supply filling sand for Ommoord and Zevenkamp and is used for recreation, with a small harbour, and nature. A beach is created alongside a boulevard like a real coastal city with large-scale building blocks and some family houses. Here the central facilities for the whole of Nesselande are brought together: library, shops and an entertainment centre.

The subdivision of Coast City is characterized by difference in heights that are introduced for functional and spatial reasons: to lift the boulevard over the beach and the lake. On the inland side the height difference with the lower lying Garden City is solved with a patchwork of height differences in the layout (the association with a dune landscape is made by the designers). In this manner the building-site preparation is strongly connected to the desired city type and affects the public space, beneath which a convenient car park is situated.

Garden City consists of two parts with different ground levels; the northern part is filled in 1 m and the southern part only 15 cm. The water that is transported through the park to the north side returns through the water system in Garden City. This system has to pass a dike and new dikes make a separate polder.

Due to the fact that there are regulations for the residents the water remains in quite a good condition. Washing cars is prohibited, garden furniture cannot be of impregnated wood, zinc, copper or lead; dogs can be walked only in special places (where the rainwater ends up in the sewer and not the open water system), the use of chemicals is prohibited in the gardens as is fertilizer. Lava boxes are placed under the parking spaces to filter the water before it goes into the ground.

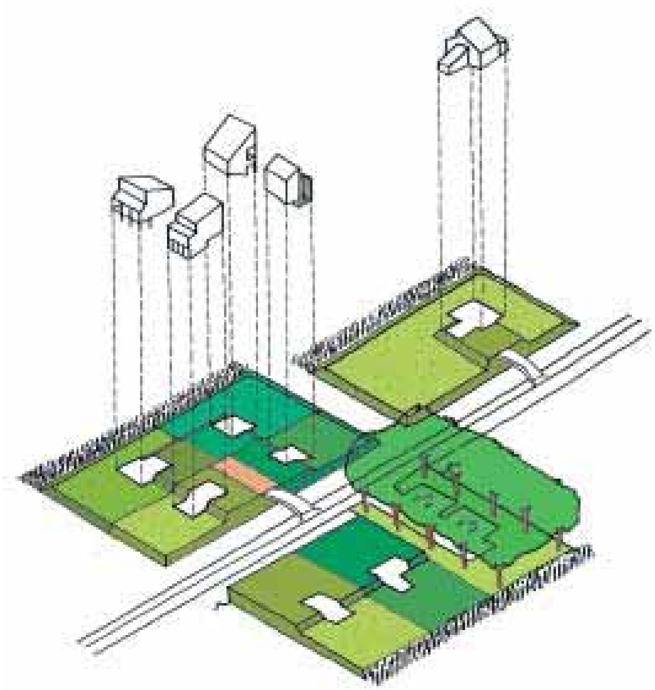
Picture 6.5 Water City by Palmbout Urban Landscapes and H+N+S Landscape architects
Source: Palmbout Urban Landscapes and H+N+S Landscape architects

The third urban environment is Water City, designed by Palmbout Urban Landscapes and H+N+S Landscape architects. The main structure of this city is like a game of jackstraws, made up of a system of dikes that connects the Water City to the surrounding tissue with roads situated on top. These dikes also divide the area into different ‘rooms’ and protect it from the water in the lake. The second layer of the plan is a system of water courses and islands following the original polder structure. The roads are at an even distance; the water courses have different widths. The combination with the jackstraws system creates a differentiated and labyrinth-like landscape.

The third layer is a system of diagonal water courses to differentiate the spatial pattern and give definition to the residential strips. Because these water courses are oriented towards the different wind directions they play an important function in the water exchange between the lake and the residential area.

In Water City there is private development of individual housing without aesthetic supervision by the municipality. This notion of freedom of design is part of the discussion concerning the strict regulation of building conditions in the Netherlands. Here the upper class may build in its own style and taste.

Without aesthetic supervision the designers introduce a strategy to enable them to have some control over the arrangement of houses on the individual lots. They use building-site preparation as an invisible tool. The ground level of the lots is 4.80 m -MSL and guarantees a direct relation between the water and the gardens; the dikes for the roads are 80 cm higher (4.00 m -MSL). Where the house should be situated, in connection with the road, the lots are filled in to 4.00 m -MSL to form an artificial dwelling mound on the total lot. The architects of the individual houses are challenged to make use of this height difference and the position of the mound on the lot in their architecture. This strategy will not only guide the dimensions of the buildings but also the set up within the urban tissue.[653]



Picture 6.6 Principle of the artificial dwelling mounds that orienting the position of the buildings.
Source: Palmbout Urban Landscapes

Nesselande in 2011

Nesselande is the last expansion within the VINEX programme for Rotterdam. The Coast City, the Garden City and the Water City of Nesselande are all still partly under construction. Most of the houses are built and the public space, the lake, the park and the water structures are finished. The residential area close to the highway and the recreational area of the Zevenhuizerplas are quite popular. The Zevenhuizerplas is an attractive recreational area, not only for residents but also for people from other parts of Rotterdam, The water system offers enough buffers for heavy rainstorms

[653] Interview with Frits Palmboom on January 8th 2009, and Meyer 2003

and the quality of the water is turning out to be very high.

The use of building-site preparation to steer urban development seems to have some difficulties. Due to the fact that not all private developers use an architect to design their houses but frequently choose from a catalogue, the adaptation of the architecture to the artificial dwelling mound is not happening. In many cases the mounds are enlarged to the size of the whole lot and the house can be placed anywhere making no connection to the conditions of the lot.

The importance of water in Nesselande and the method of building-site preparation has largely been steering the urban design. The urban context has been adapted to the fact that there are very wet conditions and advantage is even taken of this. Constructions and structures have been used to make the independent polder and water system, and ecological measures taken to ensure the water remains of good quality. The relation to the original landscape is made in the Water City only by taking over, or responding to the original polder structure. In the Water City and the Garden City the landscape is altered to create the desired urban environment. However, some use of technology is made for design concepts like the dunes in the city on the waterfront and a separate water system with an ecological park. This shows some relation between the urban design and the technology used for building-site preparation.

The characteristics of the Fine Dutch Tradition in this project are marked by the overall importance of water to structure the area, the attempt to make the residents aware of the wet situation of their neighbourhood and the way the water has been added as a spatial quality for living and recreation. Increasingly the technology of water is again becoming an obvious aspect of the spatial order, the return of the Fine Dutch Tradition. A new element of the Fine Dutch Tradition, or maybe a forgotten element, is public awareness. Before technology guaranteed dry feet most Dutch were conscious of the circumstances in which they lived. Today people have no idea and feel no responsibility towards the wet circumstances. An attempt is made to bring this back In Nesselande by employing regulations.

Rotterdam Polder Zestienhoven

Picture 6.7 Drained lake Rijs en Daan 1820
Source: Hoogheemraadschap Schieland en de Krimpenerwaard

The latest 'new' polder expansion in Rotterdam is Zestienhoven. Before the twelfth century the area is part of a large swamp in Middle-Holland. At the edges of this area, close to the Schie River a large peat area is formed. The first dike ring is built around 1170 where the Oude Kleiweg, Overschiese Kleiweg and Kleiweg are now. Thereafter the polder Zestienhoven is reclaimed with the cope-system (fan-shaped pattern of lots). From the twelfth century peat mining slowly starts and from 1530 to the eighteenth century large-scale wet peat mining is done and the Zestienhovense Lake develops. This lake is pumped dry around 1786 and the polder is reclaimed with a stroke parcelling with a northeast-southwest orientation, except for the southern part that had a southeast-northwest orientation.[654]

Perpendicular to the polder pattern a few *tochten* (draining ditches) are dug as main discharge routes. The wet peat clay polder is used for cattle and farms are built along the Overschiese Kleiweg and the Bovendijk. In the 1920s and 1930s more and more houses and businesses are built along these two ribbons and some horticultural businesses with a few greenhouses appear. The first sports facilities are also built in the 1930s and in the 1970s around the Mokweg. Some ditches are filled in and the area is filled in. North and south of the Overschiese Kleiweg allotment gardens slowly grow into large complexes in the 1950s. A garden complex is also built south of the airport around 1965. For all these complexes the polder pattern is used to make the layout of the gardens and little houses.

After the Second World War the municipality decides to move the business airport from the Waal Harbour to the Zestienhovense Polder

[654] Kamphuis and Backer 2009, 6

because there is more space available. In 1971 the strip is moved north and the Bovendijk is rerouted.

What is left of the area is developed around 1970 as a park area and around this area the Beekweg, Terletweg, Mokweg and Van der Duijn Van Maasdamweg are laid out. The old polder pattern is buried under a layer of black soil and sand and trees are planted. Between 1974 and 1983 the west side of the Van der Duijn Van Maasdamweg is exploited by the municipality as dumping grounds. In the 1980s this area is also covered with soil and planted with trees.

Until the twentieth century the ribbon along the Overschiese Kleiweg remains agricultural in character, after the 1920s it slowly transforms into a more urban area with urban villas and gardens.[655]

The water system is still a very important structuring element in the polder with recognizable ditch parcelling, water forms the borders of the polder and there are some little lakes in the area. The Zestienhoven Polder is about 4.5 to 6 m below MSL and suffers from quite severe seepage. The dikes of the polder are of peat and therefore not very stable. The houses along one of the dikes, the Zestienhovensekade, used to move due to the unstable ground. Because these houses moved around people call them *schuifhuizen* (shifting houses).[656]

The groundwater level is quite high and in the polder several different levels are present. These different levels are due to the continuous cycle of draining, resulting in subsidence and then draining deeper and so on. The water is nutrient-rich and the quality is not very good due to the peat, inlet of water and overtopping of mixed sewers. In periods of severe rainstorms the area can flood due to the high surface water level in combination with the high groundwater level. This is especially the case for the IJskelder, the public gardens and the park. Also, the soil is impermeable and draining the rain towards the ditches is very difficult. The result is complete saturation of the soil during wet periods when there is also little evaporation.

MER

Expansion in Zestienhoven is necessary to address the shortage of a high-income category housing; the area is part of the so-called 'green carpet' (a green and ecological connection between Rotterdam and Middle-Delftland combined with water storage) and will have a business area to add to job opportunities. These aims are included in the *Ruimtelijk Plan Rotterdam 2010* (Spatial Plan Rotterdam 2010), *Nota van Uitgangspunten voor Polder Zestienhoven* (a set of starting points for Polder Zestienhoven), and *Master Plan Zestienhoven*. In 2003 the municipality considers the area an excellent location to solve the need for higher income residents and proceeds with a Milieu Effect Reportage (MER) (Environmental Impact Report). Such a report is obligatory for a development of this size according to the Wet Milieubeheer (Law on Environmental Management) of 13 June 1979, which also regulates a few more general subjects in the area of environmental hygiene.

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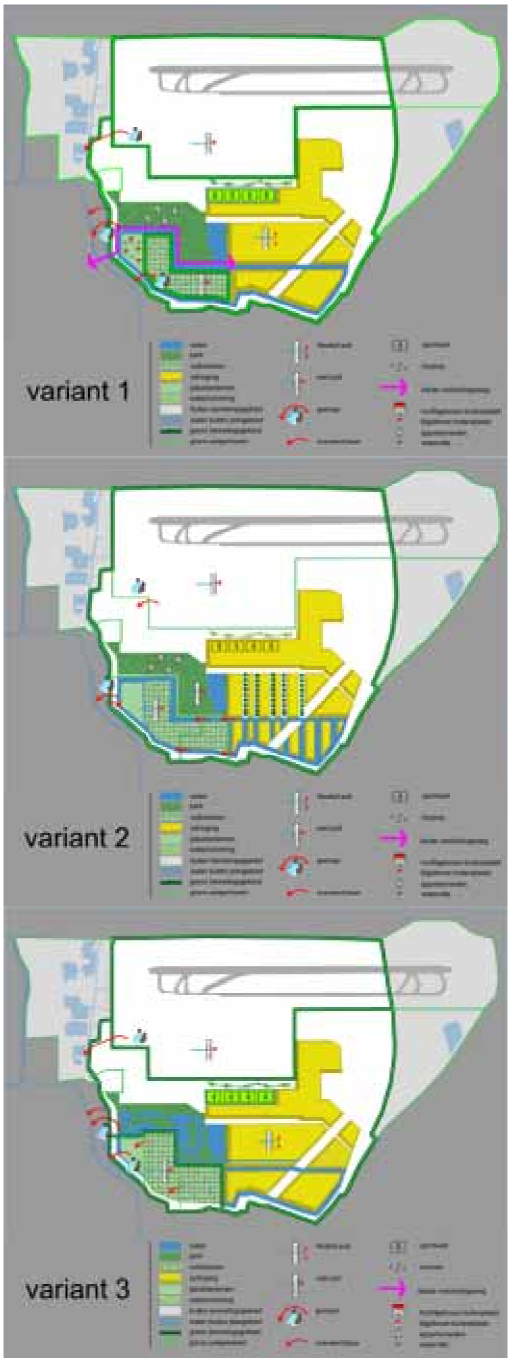
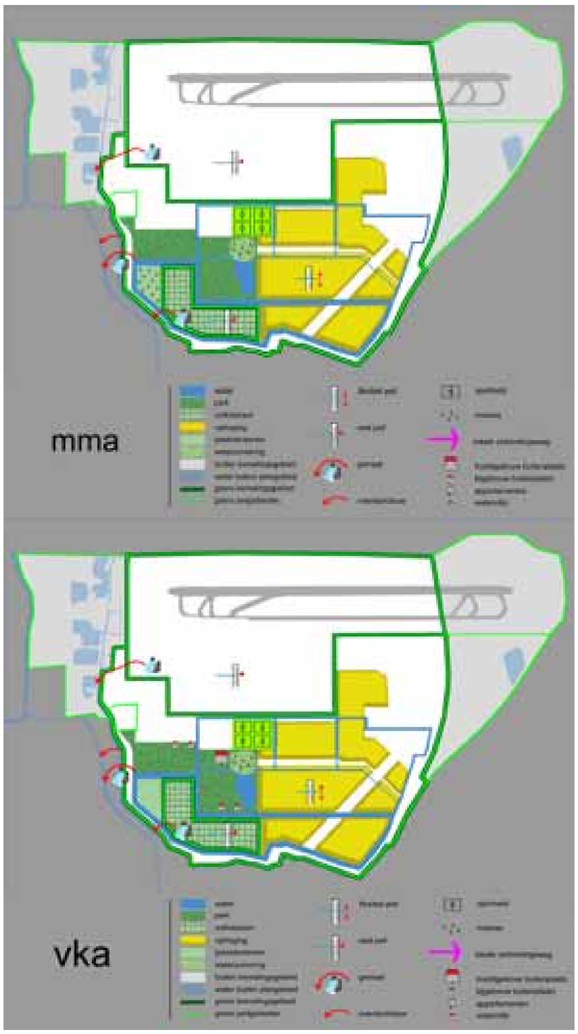
[655] Anonymous 2002
[656] Burgdorffer 1918, 73

A MER report is a quite extensive research into all the subjects concerned: traffic, water, soil, culture, history, landscape, nature, recreation, environment, air, noise and producing different scenarios. The choice of scenario results in a master plan. The master plan is the centre of discussion throughout the whole process towards an urban design, which then leads to eventual realization.



Picture 6.8 In the MER three scenarios are tested to consider the following subjects: water system, IJskelder (small rudiment of a peat area), extra infrastructure connecting Overschie, building in the existing park and the method of building-site preparation
Source: Gemeentewerken Rotterdam 2004

The Master Plan for Zestienhoven identifies three parts of development in the area: Hoog, Middel and Laag Zestienhoven. Hoog Zestienhoven is for business and residential functions, but because the development is dependent on the new plans for a highway and train station it has been suspended until 2015; Midden Zestienhoven is for businesses and housing as a part of the green carpet and connection to the Randstad rail (light rail); and Laag Zestienhoven is for low-density ground-bound houses, public gardens and sports facilities.



Picture 6.9 From the three scenario's the *Meest Milieuvriendelijke Alternatief* (MMA, Most Environmental Friendly Alternative) and the *Voorkeurs Alternatief* (VKA, Preferential Alternative).
Source: Gemeentewerken Rotterdam 2004

Three scenarios are tested to consider the following subjects: water system, IJskelder (small rudiment of a peat area), extra infrastructure connecting Overschie, building in the existing park and the method of building-site preparation (see illustration 6.8). The effects of the different scenarios are evaluated and the alternative that proves best for the environment is chosen, in this case the water system is the most decisive subject. The chosen scenario is then improved by advisors, urban studies, financial aspects and future connection possibilities between Polder Zestienhoven and Overschie.

The scenario has the following variables that shape the master plan: the water system is split up into a separate part for the airport, a main system and a system for public gardens (the main system is flexible and the system for gardens has a fixed level), houses in the IJskelder have a water and swamp environment and an extra connection to Overschie, the west side of the park and the area will be integrally filled in except for the park and IJskelder. The three systems will be pumped to a *tussenboezem* (an extra step to the main discharge channel), this is very positive, especially for the water quality. Also, to maintain the quality no outside water will be let into the system. This means that for times of drought enough water has to be stored in the system and a flexible level needs to be realized. Maximum level is 6.00 m -MSL and the level will vary between this and 6.50 m -MSL due to the fact that the seepage in the area is quite large. The level in the gardens will be maintained, a lower level of the surface water would lead to more subsidence.

Midden and Laag Zestienhoven have a water system that will offer enough space to prevent flooding and that is inspired by the original landscape or parcelling structure. The lowest part of the area is chosen to make a wide water course; this turns out to be a very bad choice afterwards due to the fact that the seepage here is very severe. In contrast to the chosen scenario the IJskelder and the park will not be built and no connection will be made to Overschie. From studies it becomes apparent that both the park and the IJskelder have high natural qualities, and the IJskelder is historically recognizable as cultural landscape and therefore a spatial artefact.

For building-site preparation integrally filling is chosen to prevent the inconvenience of high groundwater and subsidence of the private gardens, enabling the simultaneous development of the area and reducing the chance of breaking up watercourses by the pressure of the seepage.

For the IJskelder two possibilities are defined. One is to have the area return to its natural habitat as a swamp; the second is to preserve the cultural landscape. The first will happen naturally as an effect of the choice of water level and keeping the area free of houses. The second can only be maintained if the lots are also filled with soil.

Influenced by a plan from the users of the public gardens (Plan Ieders Land) it is decided to keep the IJskelder as an artefact of the original dried lake landscape. This choice is not irreversible and therefore easy to make. It does raise the question: What is nature? Considering the choices that are made in maintaining the water system, the natural outcome will be a swamp. But for the residents the natural experience is apparently the cultural landscape, which will have to be preserved and maintained ‘culturally’.

Picture 6.10 Subdivision layout in September 2008
Source: dS+V Rotterdam

Water Directives

In cooperation with the water board an intensive study is made into the water system in the area. Both the MER and the master plan contain the results of the study and work within the framework of several governmental directives. The state policy is formulated in the 4e Nota *Waterhuishouding* (4th Memorandum on Water Management) (1998) and promotes sustainable urban water management. In the *Nationaal Bestuursakkoord Water* (NBW, National Management Agreement Water) the issues and responsibilities of municipalities and Water Boards are set out (2003). Also a model is provided for the possibility of inundation of urban areas from overflow of surface water. The provincial policy *Milieu en Water 2000-2004* (environment and water) emphasizes storage and *Nota Planbeoordeling 2002* (Memorandum Plan Assessment) requires a water paragraph in a zoning plan and the regulation of 10 per cent surface water in an urban area.

Following all these policies in response to the report on water management in the twenty-first century, 17 *Deelstroomvisies* (stream areas) are set up in anticipation of climate change to help the countryside to preserve and control water levels. Rotterdam is part of one of the *Deelstroomvisies* and therefore sustainable urban development is a general issue for Rotterdam.[657] Finally, the Water Board of Schieland and the Krimpenerwaard also has a *Waterbeheersplan Schieland* (2003-2007) (water

[657] Water en ruimtelijke ordening in veenweidegebieden, 'Verslag van een veldsymposium in de Krimpenerwaard'. Stichting Natuur en Milieu 5 juni 2003

management plan Schieland) for this area, which regulates quality and quantity as important issues to improve the water system. Since 2003 these issues are tested by the Water Boards and the Watertoets (water test) is obligatory for municipalities. In this the Water Boards test whether the proposed water system is adequate. All these different regulations have been taken into account when developing the water system of Zestienhoven.

Picture 6.11 Zestienhoven under construction, building-site preparation activities consist of moving around a whole lot of soil
Source: Author

Urban Engineering

To investigate the relation between the technology used and the urban design the urban designer and the engineer of the municipality, respectively Mattijs van 't Hoff and Peter Spakman are interviewed.[658]
Spakman is already involved in the project from a very early stage, but not from the beginning. Van 't Hoff took over from a colleague after the master plan was finished. Even though the master plan is made taking into consideration all possible aspects, including the highest possible sustainability of the water, in the development of the plan to realization, those interviewed come across problems that mark the relation between technology and urban design.

The water board stipulates that the required 10 per cent open water be situated at the southern border of the area. This broad canal is drawn up by the urban designer, influenced by the landscape type that characterizes the area. When the canal is calculated by the engineers it transpires that the

[658] This interview is conducted by the Author on October 1st at the dS+V in Rotterdam .

seepage in this area is such that it will be very expensive to make a broad canal: the bottom needs to be covered with a heavy and expensive weight to keep the seepage from surfacing.

According to Spakman these details become apparent only after calculations are made. Moreover, the location of the water is chosen for design reasons and not on the basis of technology or soil conditions. The master plan is thus an agreement between technology, urban design and finance made not generally, but specifically having regard to the features then important to the stakeholders. Spakman argues for an agreement made on broad terms, where generalists from the interested parties in technology, urban design and finances consider their interests within the context of the interests of the other stakeholders. This will lead to a more general plan to form a solid base for technology, urban design and finance. The broad waterway is impossible both technically and financially and another design has to be made.

In the meantime landscape architect Anne Mieke Backer is appointed as curator for art and green areas. The first thing she sets out to do is have a historical analysis compiled for the area. Although the MER has some information, she says that especially concerning the landscape and all its different assets in the area, a biography of the area is necessary to understand the coherence between all these assets. Mariëtte Kamphuis is asked to do this research.[659] Her point of departure is Zestienhoven as a historically frayed border characterized by the huge number of left-over functions parked in this area. The biography starts with the name and origin of the polder as a part of the Ambacht van Overschie, which is also called the Ambacht of 64 courts, of which Zestienhoven has, as the name states, 16 of these courts. One court is a piece of land sized 30 *morgen* (morning), a *morgen* (approximately one hectare) is such a size that it takes a farmer a morning to plough. Kamphuis finds the history of the development of the area in the research of J.J. Voskuil (1926-2008), researcher at the P.J. Meertens Institute, who investigated the taxes of Overschie in the sixteenth century (1982). The tax administration enabled Voskuil to reconstruct the landscape through the ownership of lots.[660] Since the water system is identical to the ownership system this type of information can be enlightening about the water system too.

Kamphuis also uncovers some historical maps from the Municipal and Water Board Archives such as the map of the Water Board of Delftland (1712) done by surveyors Nicolaas and Jacob Kruikius in which spatial characteristics of the area are also visible.[661]

When a new design for the broad water way has to be made this historical research offers the solution. On the historic maps there is a strip along the area with small islands on the parts of lots that are not usable. This morphology is applicable to the strip where the broad water way was planned. Along the small existing water way a new water way is projected (as far from the dike as possible) and in between the two waterways small islands with their own environments are located. The logic of this design is

[659] Kamphuis and Backer 2009
[660] Voskuil 1982
[661] Kamphuis and Backer 2009, 1972 Architecture Institute, Archive Van den Broek en Bakema (BROX) 2185, Rotterdam, ideeënschets voor woningbouw op Zestienhoven: d2185, 2185t1 - t2, 2185t3547, 2185t3548

based on hydrology that never really changes. Hydrology is like a time machine that creates conditions for all times.

In an earlier Phase of the master plan the urban designer took another starting point, the wide waterway originated from respect for the landscape structure of the polders and emphasized this structure. The landscape structure is considered to be more important than the soil conditions in the area. That is why Spakman suggests bringing together generalists at an early stage. Urban designers think in images and engineers in numbers, sometimes it is difficult to grasp the basic elements of each other's disciplines.

Two Historic Plans

Another interesting aspect of history is that it can offer insight into a given context. The historical research also presented two plans by Piet Verhagen (1926) and Van den Broek en Bakema (1976). In these plans a way of dealing with the soil conditions is apparent.

The plan by Piet Verhagen (Granpré Moliere, Verhagen en Kok) is made in line with the development of Blijdorp which in 1926 was still under debate due to the uncertainties concerning rail and road (see chapter 5a). The garden city concept that he applies to the design of Vreewijk (in Rotterdam South) is also used here, even though the scale of the project, 7,000 houses, is much larger. As in Vreewijk the urban design is to guarantee a good overall arrangement of the main structure, buildings and public space. This will result in an independently functional area, with its own facilities, and a large recreational area (15 per cent of the area) for different types of residents. [662] For water, a surface area of 5 per cent in the shape of ditches and waterways is reserved to be able to store the surplus from severe rainstorms. The Water Board of Delftland cannot guarantee that the pumping will handle a large amount of water in the urbanized area so this percentage of water surface is required in case of an emergency. The area of 400 ha will consist of 15 per cent park or field, 5 per cent water, 8 per cent sports facilities, 3 per cent unpaved roads, 12 per cent low-density buildings (10 per ha), 19 per cent normal streets, 38 per cent normal density (40 to 50 houses per ha) of which 4 per cent are public buildings. In their explanation to the design the urban designers write that it is not necessary to fill in the area (integrally with sand) but that the groundwater level will be lowered. For this a larger pumping station is necessary. Their advisors in these technical water matters are engineers Van Hasselt & De Koning (Nijmegen) and they have some samples drilled for the soil conditions. Unfortunately neither report is in the archives but the urban designers state that the soil tests show that the conditions in the area differ a lot, which means that a careful decision should be made about different types of foundation for the houses.[663]

[662] Steenhuis 2007, 184-185
[663] Toelichting Bebouwing Laag Zestienhovensche Polder, 1 juli 1926, NAi Archief Granpré Molière, inv. Nr. 3x.2.1

Picture 6.12 Plan for the polder Laag Zestienhoven by Piet Verhagen (Granpré Moliere, Verhagen en Kok)
Source: Anonymous, no date

On 28 October 1971 the council of Rotterdam decides to prepare for the closure of the airport Zestienhoven because at that time the consensus is that an airport should not be so close to the living environment of people. In 1972 the city development department advises planning a residential area and in 1975 this is taken into the *streekplan* (landscape plan) of the province of South Holland. The municipality chooses the architectural office of Jaap Bakema (Van den Broek en Bakema) to make an initial plan. They are required to take the existing buildings in the area into consideration in their new plan.

The plan for the north side of the polder by Van den Broek en Bakema (1976) shows the typical 1970s' morphology built up of cul-de-sacs and *woonerven*. Additionally the orthogonal polder system, together with the polder on the north side, forms a solid structure in the urban design. The polder ditches are maintained in a north-south direction and perpendicular to the ditches *singels* are introduced to complete a water system that relies totally on the open water system (no drains and pipes). Also contrary to common practice in Rotterdam at that time, the use of filling with sand is not proposed as the method of building-site preparation. No more than the usual difficulties with the soil conditions in Rotterdam are expected.

The urban designers use the dimensions of the polder water grid to structure the area in islands of 450 x 450 m (this is clearly visible in picture 6.13). The allotment and building types within the islands can differ as the grid setup offers enough structure for the design to enable diversification. The ditches are formal in this design and the *singels* form a more natural element, especially since the green structures are projected around and along them.[664]

Picture 6.13 Model by Van den Broek en Bakema for Zestienhoven airport, 1976
Source: Architectengemeenschap Van den Broek en Bakema 1976, colour Sophie van Ginneken

[664] Architectengemeenschap van den Broek en Bakema 1976

Picture 6.14 Van den Broek en Bakema for Zestienhoven Airport, 1976
Source: Architectengemeenschap Van den Broek en Bakema 1976

Polder Zestienhoven in 2011

The urban context of Zestienhoven is the presence of the airfield, the park, the public gardens and the new HSL. Here a luxurious residential neighbourhood is planned with a lot of attention for the water system. The master plan is developed by choosing from different scenarios that offer optimal solutions between economics and sustainability. However, the choice for the integral filling of the residential areas is made on the basis of economics. Therefore the use of structures and constructions is necessary. The relationship of the landscape and the water system with the new use for the site is not completely lost. The polder pattern will return in the form of larger streets and some water courses, the park will not be filled in with sand and the IJskelder will be preserved as an original polder structure.

There is no relation between the urban design and the technology of building-site preparation due to the large scale of the sand layer. The residential areas all have their own logic based on the typology of housing that is planned and the profile that goes with that. For example the Vijver neighbourhood is built up out of four different types of houses (in combination with lot size) from large near the pond (*vijver*) to small on the other side. Each type has a different street profile.

Picture 6.15 Artist's impression of the new residential district
Source: dS+V Rotterdam

The urban design of the area is based on the rules of water management, the hydrological cycle, and the permanent water and soil conditions that work like a time machine. Besides open water there are now other ways to make a sustainable water system, such as green roofs, *wadis*, grey water systems and infiltration roofs. Unfortunately Zestienhoven does not make use of these measures. There is no incentive to use these methods since the water board has already covered the water issue with the rule of 10 per cent open water. This rule is made to cover the responsibility of the water board. It is a pity because the use of new technologies can mean a new correlation between the urban design and technology of water management: the new hydrological (water) city[665] – a new step in the Fine Dutch Tradition. An important new insight this case offers in relation to the definition of the Fine Dutch Tradition is that water is like a time machine and therefore historical research, in addition to technical research, is fundamental in order to make a sustainable urban design.

[665] Deltares 2009

Rotterdam's Future

Rotterdam is very much aware that, for its future, adaptation to climate change is necessary to survive the increase in water coming from above, from the river and from the sea. In order to be able to do this the city has joined the Clinton Climate Initiative and with this develops many initiatives to make the city not only waterproof but also climateproof. Mitigating measures also play a large role in these projects of which the reduction of energy use and carbon monoxide output are the most important. The projects aiming at adaptation are moreover water projects that are also strongly connected to other initiatives like the national Knowledge for Climate research programme. This research is set up by the state government for the development of knowledge and services to 'climate proof' the Netherlands. Governmental organizations (central government, provinces, municipalities and Water Boards) and institutes and universities actively participate in this research programme through the input of additional resources. The research programme aims at the development of information necessary to enable the assessment of investments that need to be made in spatial planning and infrastructure over the coming 20 years concerning resistance to climate change, and for making changes where necessary.

However, most of these projects are about flooding from the large-scale water system and are not aimed at the water issues in the polder. An important project that does pay attention to the challenges in the polder is *Waterstad* 2035. This study was done for the International Architecture Biennale in 2005 and has led to an important change in the municipal departments and the formulation of the general water plan for the city, Waterplan 2. This plan is connected to the *Stadsvisie Rotterdam 2030* (City Vision 2030) the spatial development strategy that Rotterdam made in 2007.[666] Hence, here the urban design and technology of water management are connected

Stadsvisie Rotterdam 2030 is a strategic vision of the spatial developments in close relation to the economic and social developments. The plans of Waterplan 2 are incorporated in this vision. This is very important because the water issue should be as evident as the economic and social aspects of city building. One of the big decisions in this vision is not to expand the city in large residential areas connected to the highway, the so called VINEX locations like Nesselande. Instead the strategy is to make better use of the existing urban footprint of the city, on the one hand densify the inner city, and on the other try to make better use of areas on the fringes of the city, like Zestienhoven.

Rotterdam wants to become more attractive to middle- and high-income earners and create a more attractive investment climate, not just for international and new companies, but also for the current and future inhabitants of the city. This can be achieved through investment in urban areas along the river and through the transformation of the old industrial

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[666] Gemeente Rotterdam 2007

and port areas, areas that are vulnerable to climate change and sea level rise.

One of the first official initiatives towards a sustainable city is the decision on 8 July 2008 to subsidize green roofs. In the dense city green roofs store water for a certain time, taking the load off the sewer system. Moreover green roofs also have an insulating function. This means cutting back on heating and cooling and therefore less CO_2 in the air. The last advantage of green roofs is that they absorb polluting dust from the air. On a larger scale these green roofs solve part of the pollution and water problems, and provide more greenery in the city, which increases the flora and fauna. The municipality of Delfshaven has even decided to make green roofs obligatory on new buildings.

Waterstad 2035

On the occasion of the International Architecture Biennale Rotterdam with the theme 'The Flood' (2005)[667] the municipality of Rotterdam decides to organize the project Rotterdam Water City 2035. This plan attempts to unite the three water threats of river, sea and rain with spatial quality and to make water an important vehicle for transformation and restructuring. Together with the district Water Boards a design is produced that, portrayed in a scale-model, takes the attitude: 'Water is our friend and enemy. We are providing answers to the hostile aspect by embracing the friendly aspect.' Like Rose's *Waterproject*, the threats must be transformed into opportunities, which is the essence of the historic Dutch talent.[668]

Rotterdam Water City 2035 is designed on the basis of evolving changes in the philosophy of safety that looks at the risks as opposed to what is commonly done, looking at the probabilities. This philosophy also shows more respect for natural forces as opposed to the start of the feasibility concept: that natural forces can be tamed completely. The new adaptive safety philosophy aims at the implementation of change in the urban dynamics to make Rotterdam gradually safer and thus link economics, safety and quality of life together.[669]

Plans aim at combining the space necessary to store water produced by intense storms and stocks of water to cope with dry periods (without loss of water quality) with other urban challenges like traffic, differentiation in housing, transition of the economy from a port economy to a knowledge economy and the more general theme identity. The city is changing even without a water issue and needs to be worthwhile every day and perform well under extreme conditions.[670]

There is no 'final solution' for the flood defences in 2035 given in the plan, but an adaptive strategy towards what we do not know in 2035. Information will be added in the coming decades and we will be increasingly able – by designing a learning process involving experimentation and a series of 'no-regret' measures – to work on the future.

In the design of Rotterdam Water City 2035 there is more water and importantly it gives direction to a great diversity in residential

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[667] The different publications of this Biennale are: Geuze et al. (2005) Hooimeijer et al. (2005) the catalogue of the exhibitions, and De Greef (2005)
[668] Geldof 2008, 54
[669] Geldof 2008, 55
[670] Rotterdam Waterstad 2035

environments. The city centre will be moved to the riverside on a heightened river bed that will be filled in stepwise with each transformation or restructuring. That way in time safety will increase for both the zone itself and the polders behind it. The waterside is more public and provides 30,000 additional homes designed to adapt to the dynamics of sea and river.

Picture 6.16 Rotterdam Waterstad 2035
Source: dS+V Rotterdam

The north of Rotterdam has a living environment that is highly valued and the proposed changes there resemble surgical interventions in the urban fabric. The restoration of old *singels* for the *Waterproject* will give space to collect excess water and maintain the groundwater level in areas where the houses stand on wooden foundation piles. Also, water squares will be constructed to store water in the event of extreme precipitation. The rivers Rotte and Schie will be reintroduced in the cityscape with new residential environments.

In the south of Rotterdam a network of broad stately watercourses, connecting canals and residential *singels* add to the excitement of the area and provide a counterpoint to the pattern of roads and streets. The garden city principle will be revived in the southern part. Whereas there is a consolidation of homes in the river zone and in Rotterdam North, Rotterdam South will be thinned out, creating additional space for residents with average and higher incomes.

More important than the actual outcome of the project – which may or may not be implemented – is that it works in the relationship between the organizations of the municipality. Previously the Department of Public Works and the urban design office (dS+V) did not have a smooth working relationship. Through the project they discover each other's knowledge and also learn to appreciate that knowledge as a contribution to their own practice. Working out technical and spatial plans develops into an interesting and productive exercise and since then they have worked out Waterplan 2, which is also a good combination between technology and urban space.

The Fine Dutch Tradition: Episode Seven

In the Phase where new adaptive power is to be found the ancient talent that is captured in the Fine Dutch Tradition makes a comeback. Under pressure of the changes in the hydrological system, the climate change, the pure technological approach represented in the *maakbaarheid* paradigm is abandoned and a shift is visible to what could be called the vulnerability paradigm. This change is supported by the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), which concludes that the changing climate is the responsibility of mankind.[671] The technological approach has led to an artificial water system that cannot deal with the increase in rainfall and drought. The attention for water as a spatial layer in urban development is part of the ‘new’ - or should it be old-fashioned? - approach.[672]

In the last decades some projects have been realized in which building-site preparation is used to shape the urban environment – as an instrument of urban design – and to bring the right balance between water and soil in order to be sustainable and water (climate) proof. In Nesselande and Zestienhoven first steps are taken to reintroduce building-site preparation together with an open water system as the basis of the urban design. In these projects the characteristics of the Fine Dutch Tradition are marked by the overall importance of water to structure the area, the attempt to make the residents aware of the wet situation of their neighbourhood and the way the water surface has been added as a spatial quality for living and recreation: the new Dutch water city. Increasingly the technology of water again becomes an evident aspect of the spatial order, the return of the Fine Dutch Tradition.

The paradigm of vulnerability that is characterized by consciousness about both the vulnerability of man and that of the natural system has a strong connection to the Fine Dutch Tradition. Technology made us forget about vulnerability. This paradigm offers more perspective on what qualities and opportunities the water and the natural system can bring to the urban system. Urban interventions in the landscape are made with a critical perspective on the effects of these interventions. It shows that hydrological conditions are like a time machine, a continuum that sets the agenda for future land use. Also, the time factor needs to be incorporated into the organization of urban development; technology needs to be orchestrated and balanced with the natural conditions of the site. The vulnerability paradigm is useful because it can establish the rate at which cities need to

[671] Intergovernmental Panel on Climate Change 2008
[672] Zie deltares boekje KLWM 2009

be protected, balanced with what a city can sustain. It offers the link between the Manipulative attitude and the move towards the adaptive attitude.

The search for balance between adaptation and attention is well under way, illustrated in the return of the relation between the urban design and the physical geography in considering the landscape (but not yet the soil and subsurface) as carrier of the hydrological system and the awareness of the necessity that this be able to cope with the future changes in the hydrological system.

Another important issue is represented in an adaptive attitude wherein the different professionals are open towards each other in a generalist approach and do not introduce their specific preferences at an early stage. This calls for a conscious handling of knowledge and fitting it into the planning process on the one hand; on the other the sharing of knowledge like the Geocheck that makes information about soil subsurface and subsidence more easily available.

The relation between urbanism and the technology of dealing with wet and soft subsoil is important in building cities that can 'move with nature' and have a multifunctional use of every inch of space. The Fine Dutch Tradition expressed in the new Dutch water city can return to its roots: complex urban developments that connect different challenges in the most efficient way.

Chapter 7: The Power of a Tradition

Historical overview and its analyses

Next to the Systematic Analysis of the development of polder cities, the other promise of delivery of this research is the analysis of the information resulting in conclusions. Goal of the analysis is to find continuity and fundamental characteristics that form the red threat in the story of the Fine Dutch Tradition. This red threat gives insight into how civil engineering and urban design relate - which is useful when tackling the current issue of making cities water (and climate) proof. The continuity and fundamental characteristics clarify the meaning of the Fine Dutch Tradition in urban development, which is shown in the conclusions, the closing paragraph of this chapter and research.

In preparation of the analysis two questions need to be answered: What is there to learn from this study and what type of analysis brings about the Systematic historical overview?

The logical answer to the first question is that (except for the inner city of Rotterdam) all the cases still exist. These areas are still inhabited and are also suffering from the effects of climate change. That is also the reason why in the Systematic Analysis the choice has been made to briefly describe the current situation. In the development of cities, at any time, there is the concept of *longue durée* to take into account.[673] This investigation analyses the *longue durée* of urbanization in its relation to the wet and soft soil conditions in the Netherlands. This will direct thoughts to the possible relevance of historic concepts, interventions and approaches to present-day problems. Niccolò di Bernardo dei Machiavelli (1469-1527) even claimed that:

> Whoever wishes to foresee the future must consult the past; for human events ever resemble those of preceding times. This arises from the fact that they are produced by men who ever have been, and ever shall be, animated by the same passions, and thus they necessarily have the same results.[674]

Lewis Mumford joins Machiavelli in proposing: 'Without a long running start in history, we shall not have the momentum needed, in our own consciousness, to take a sufficiently bold leap into the future.'[675] Mumford defines specific regional conditions in geographical qualities (soil conditions, climate, vegetation, agriculture, technical exploitation) that are of all times, and the existence of a dynamic balance with the region. Here he makes the connection between social and geographical aspects the main motive for studying history to gain a perspective on the future, because according to Mumford social behaviour within the given conditions of the region is the

[673] Braudel 1949
[674] Machiavelli in Viroli 1998
[675] Mumford 1961, 11

basis of history.[676]

Thus history sets out lines into the future to enable understanding of the contemporary context. The Systematic Analysis of this research underpins Mumford's argument in exposing the Dutch case where the wet and soft soil conditions as a common enemy have resulted in a strong feeling of citizenship and powerful tradition in water management and the basis for urban design (in practice and form). Thus the wet and soft conditions created the social and physical frameworks and/or traditions.

The functionality of history is that it sets out lines that can be drawn into the future to be used as guides. History gives you a range of choices; it forms ideology (the possibilities and their form), it shows what can and what cannot be, what signs we use. Saussure (1974) defines the signifier, the form, the object, and the signified, the subject, the concept and/or context.[677] Historical urban forms are the signifier of the relation of the development to the characteristics of the landscape, the Dutch Water Cities. Signified is the logic between social, economic, technical and territorial circumstances that ultimately delivers the form of the city: the Fine Dutch Tradition. This logic is necessary to really understand the development of cities, to be able to apply knowledge to future developments, and thus to continue the line.

Systematic Analysis

Social, economic and technical relationships are geographically defined and result in very specific city shapes. The Systematic Analysis that is developed in this research shows that these city shapes, especially in the Netherlands, are strongly connected to the method of building-site preparation. The fact that the state of the territory and the building methods are closely related becomes very obvious when a type of building-site preparation is connected to a non-corresponding urban form, as is done in picture 7.1. Here it becomes obvious that scale, the method of building-site preparation and urban typology are strongly connected. In picture 7.2 the opposite of Brutalism building type on the artificial dwelling mound method of building-site preparation is also non-corresponding: building a small-scale development on a very large layer of sand as is done in Almere. Alderman Adri Duivesteijn's aim is to return to organic urban design with small-scale development by private builders. However, this is done on a vast layer of sand not having any relation to the smaller scale of the buildings or the landscape.[678]

[676] Mumford 1938, 310
[677] Saussure 1974, 67
[678] http://www.ikbouwmijnhuisinalmere.nl/kavels_in_almere/homeruskwartier/homeruskwartier_oost checked may 5th 2011

Picture 7.1 Brutalism building type on the mound as method of building-site preparation.
Source: Author

Picture 7.2 Private developments on the beach, Homerus-quarter, Almere
Source: Municipality Almere

The relation between scale, method of building-site preparation and urban typology is different and characteristic of each attitude towards the natural system. This analysis will specify this explicit relation into urban archetypes for each Phase.

It now becomes clear what type of analysis the Systematic historical overview brings about. To be able to find the lines and logic through time, comparable features of each Phase need to be ordered. Logic that comes out of the different phases of the systematic analysis can be more precisely defined by the use of fundamental characteristics that form continuity of meaning and impact. Per phase this logic, these fundamental characteristics, result in an urban archetype.

The analysis that results in exposing continuity and fundamental characteristics are shortly recapitulated and connected to the urban archetypes

The most important features from the defined Phases are taken from the Systematic Analysis and compared in table 7.1. Since the cumulative effect of the developments during the Phase of manipulation results in three different practices of urban design, table 7.2 shows the most marked differences between these three episodes of the Fine Dutch Tradition.

The tables in themselves offer enormous insight into the coherence of development per Phase and also the lines of development and their logic per feature. Features are grouped in three categories of scale and levels of abstraction: contextual, disciplinary and the spatial interventions. An analysis is set up in these three categories that discuss the different features together, resulting in a more precise definition of the urban archetypes representing the attitude towards the natural system per Phase of the framework. Themes which are a constant challenge present in the Fine Dutch Tradition are represented by the urban archetypes. One of the questions in the introduction to this research is how the organic and Parctical Models of Kevin Lynch balance out in the type of polder cities that are defined in the Systematic Analysis. These two models will also be used to give a more precise definition of the urban archetypes.

Table 7.1 Systematic Analysis in comparable features.

	Phase	Nature & defence	Anticipative	Offensive	Manipulative	Adaptive Manipulative
	Chapter title	2. Natural Power	3. The Power of Unity	4. The New Power	5. Accelerating Powers a_Machine/ b_Man/c_Flower Power	6. Adaptive Power
		AMPHIBIOUS CULTURE		**LAND CULTURE**		
	Year	-1500	1500-1800	1800-1890	1890-1990	1990-
Context	**Marking technology**	Ditch, Sluice, Mound, dike	Pre-industrial Mill	Industrial Steam	Industrial combustion engine (diesel, petrol), electricity	Post-industrial data and service society Computer
	Paradigms	Adaptation Paradigm	Fertility Paradigm	Systemization Paradigm	*Maakbaarheid* Paradigm	Resilience Paradigm
	Context	Nature over culture	Diking and, reclamations	Drained Lakes	Reallotment	Nature
	Society		Land of cities	Constitution	Welfare state	Globalization
	Scale		Country vs city	Birth of the national state	Stabilization of the national state	Regionalization and internationalizati on
Disciplinary	**Urbanism**	Urban develop-ment	Urban engineering	Urban engineering + landscape	Urban design (housing)	Urban design + landscape
	Skill	Craft	Experience building a body of knowledge	Knowledge development	Scientific knowledge	Multitasking, multi-functionality, governance, negotiated knowledge
		Craftsman	Military	Engineers	Specialization	Generalists
			Early Modern Period (Taverne)	Modern Period (Van der Woud)	Modernization	PostModern Period
	Focus		Rationality	Hygiene	Transparency	Sustainability and resilience
	City type		Closed city	Open city	Multistructure city	Network city
	Issue			Waste, train	Car & Stone Housing	Water/climate
	Urban Strategy		Functional adaptation	Functional concentration	Functional separation	Elastic Frameworks C2C, ecosystems
	Organizatio n		City factory	Department of Public Works	Department of Urban Planning and Housing	Urban development Authority
Spatial Interventions	**Coherence of Urban structure**		Water, road and building	Water, road and building	Road and building main structure, water and green separate	Integration of black, blue and green infrastructure
	Relation to the territory	Urbanism is physical geography	Urbanism follows physical geography	Urbanism influences physical geography	Urbanism ignores physical geography	Urbanism reintroduces physical geography
	Water function	Drinking water and transport	Drainage and discharge representation	Public space	Recreation	Nature and architecture
	Relation urbanism and water	High and dry city	Peat Polder city	Pumped city	Drained city	Sustainable city
	Brown			Water supply city	Sewer/drained/ waterway city	Water cycle/ water sensitive city
	Building site preparation	Mound, dike	Encircling canal, mud	Lowering groundwater table, sand	Hydraulic filling integral filling	Partial filling
	Urban model	Mound, dune, and river cities, Dike, dam, *burcht* and coast, cape, key cities	*Boezem*, polder and fortification city	Polder city	Garden city Neighbourhood city 'Cauliflower' neighbourhood	New Dutch water city
	Urban Archetype	**Adaptive city**	**Fertile city**	**Systemized city**	***Maakbaarheid* city**	**Resilient city**

During the Manipulative Phase technology becomes increasingly refined and enforces continuous scale enlargement. This trend produced three episodes in the Fine Dutch Tradition. Accelerating machine power is the episode in which the natural system is slowly conquered but due to imperfect technology some connectors to the landscape are still part of the city. The episode of accelerating manpower is characterized by demands from the social and economic systems determining the urban design and technology making every desire possible. The natural system is not an issue. The last episode is accelerating flower power, drawing the contours of the beginning of the awareness of the strain man puts on the natural system and the defects of the technical system in changing climate conditions.

Table 7.2 The Manipulative Phase has three episodes

	Manipulative attitude towards the natural system		
Title	5a. Accelerating Machine Power	5b. Accelerating Manpower	5c. Accelerating Flower Power
Year	1890-1940	1940-1970	1970-1990
Society	Constitution	Welfare state	In search of new relation state-civilians
Disciplines	Specialization of the disciplines	Division of the disciplines	Positioning of the disciplines
City type	Garden city	Neighbourhood city	'Cauliflower' neighbourhood
Rebekka Brown	Sewered city	Drained city	Waterway city
Building site preparation	Layer of sand with connectors to the natural system	Layer of sand without any connection to the natural system	Partial layer of sand and connecting to the natural system
Water function	Public space	Recreation	Nature
Coherence Urban structure	Road and building main structure, water and green separate	Road, building, green, water inseparate layers	Road, building, green, water all separate layers

Contextual

Social and economic conditions are of importance in trying to define the logic for each Phase of the framework. However, for this investigation emphasis is put on the territorial and technical circumstances as drivers of urban design. Different Authors have looked into the social and economic conditions on which urban developments are based. Their conclusions are gratefully used. The line that can be drawn is a trend towards better organization of social and spatial demands and putting this to the best economic possibilities. Burke writes in his conclusions:

> Finally, it may occasion some surprise that the Dutch people, whose character bears such strong traits of individualism and conservatism, should have accepted the principle of control of developments in the interest of the community and in accordance with a comprehensive town plan. The explanation may be that a people whose ancestors built the dikes and struggled to hold them against an age-long enemy inherited the tradition of acting in concern for the common good; or that the issue of draining land and preparing it for building was

> beyond the capacity of individuals; or that the prudent Dutchman, accustomed to looking to, and planning for, the future, saw in the orderly development of his town a sound and secure field of investment. . . . That plans for so distant a future were brought to fruition is evidence of their basic soundness, of their general acceptance by the majority of citizens and of the confidence they inspired in investors. The art of town planning has been defined as the art of creating the kind of environment needed to produce and maintain human values, which means, *inter alia,* the balancing and harmonizing of public and private needs so that one shall not be sacrificed to the other. In any urban activity can be said to have approached the ideal, it was the making of Dutch towns.[679]

Abrahamse in his study comes to the same conclusion: the last expansion of the *Grachtengordel* was done with the experience of the three former expansions in technology, and primarily, in organization and finance. Abrahamse writes about an 'urban concept' that merges functionality and aesthetics with economic feasibility.[680] This is very interesting because this concept is based on the 'urban principle' of digging a canal and using the material taken out to fill in as building-site preparation as has been done from the beginning of the settlement along the Amstel. This urban principle is characterized by the balance between land and water: the method of building-site preparation is strongly connected to the social and economic circumstances and results in the urban form.

For a later Phase of the Offensive attitude Van der Woud investigates the relation of the spatial order to the social, economic and legislative orders of which, in his vision, architecture and urban design are the spatial expressions. In this way he can connect society and urban design in the nineteenth century and clarify the birth of urban planning in the Netherlands. He looks into the connection between the fields of knowledge of economy, law, civil engineering, geology, demographics, medicine, sociopsychology, climatology, urban and architectural design, military, politics and policy, and the expression of these in the spatial objects to enclose the coherence between these elements.

When studying the relation between water management and urban design, reading Van der Woud's dissertation, *Het lege land* (Empty Land), is frustrating while simultaneously evoking admiration for his accomplishment in making water a self-evident part of the spatial order. Van der Woud explains:

> Spatial order is an abstract term with analogies to cosmic order, social order, economical order and juristic order. It proposes an internal coherence, a certain construction, consciously or not made by humans. This order can be so complex by nature that it can be a paradox, chaotic and difficult to understand. Spatial development and form can be a part of the spatial order, the material part. The order itself, however, is more than material and contains next to the

679 Burke 1956, 163-164
680 Abrahamse 2010, 157

> human-made elements like bridges, the polder level, the cities, the dikes, also the deformed, the chance growth of shapes, and next to the built also decay, next to what is measurable and weighable also the relative relationship between space and time, speed and slowness, mobility and stagnation.[681]

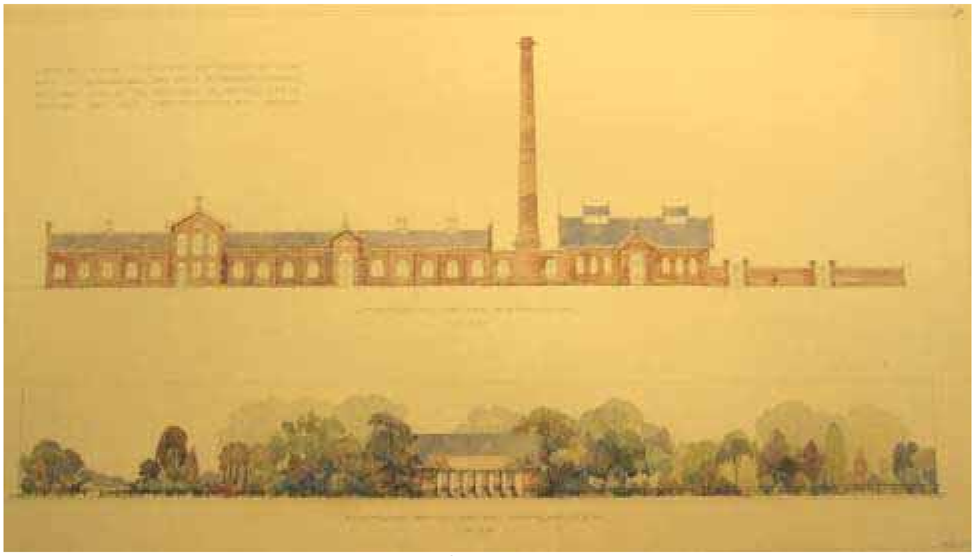
To be able to get a grip on the relation between the characteristics of the territory and the spatial order within the complexity that Van der Woud describes, the first conclusion of the analysis may be that setting up a phasing based on the technological possibilities and attitudes towards the natural system has been very profitable. The main order is brought by the Industrial Revolution between 1850 and 1890 (in the Netherlands), marking the change from Amphibious Culture to Land Culture. In the Amphibious Culture the natural system of land and water coincide and is first accepted, then ordered for defence and then anticipated. Industrialization brings about Land Culture, wherein the perspective changes from how to make best use of the territory to how to make best use of the given technology to make that which is desired from a socioeconomical (cultural) perspective. From then on technology scales up water management and urban development simultaneously.

The Line of Technology

The meaning and impact of the line of technology is evident. It marks the perspective on the territorial conditions that is used by water management and urbanization. In both cases it is a story of scale enlargement on the one side and refinement and organization of better and more effective methods of dealing with the soft and wet circumstances on the other. Building-site preparation is the common ground between water and soil management and urbanization. Before the Industrial Revolution it is handled by one person or discipline and done taking the balance between soil and water into account. After the Industrial Revolution the state of the natural system (soil and water) and urbanization are separated by the integral layer of sand that seemed to make it possible to build everywhere, no matter the soil conditions or type of landscape.

A nice illustration of technology scaling up urbanization on the one hand and refining technology on the smaller scale on the other is a drawing by the engineer of public works in Rotterdam (1915) that compares the size of a building necessary to house a steam pump to one for an electrical pump. The latter is so small that it leaves enough room for a small forest.

[681] Van der Woud 1987, 15-16



Picture 7.3 Comparison between the size of the steam pumping station Boezemsingel and the new electrical pumping station Heemraadsplein.
Source: GAR Plaatstelijke Werken port 4F1 (1915) nr 2714

The second impact of the line of technology is the trust that is put in solving man's vulnerability to nature. The refinement of technology in the last decades of the twentieth century makes it possible not only to maintain that which is threatened, but also to elect for an increasingly vulnerable place in the game between water and land. The last Phase is precipitated by the oil crisis (1973) and the Club of Rome (1972) bringing realization of the exhaustibility of fossil fuels and reawakening the consciousness of the natural perspective. Water nuisance in the soil-sealed cities in the past decade brought attention to the ecosystem and water system in the cities. New solutions are under way that no longer exploit but preserve the ecosystem, such as discontinuation of the paved surface.

Trust in technology grew at the same pace as the vulnerability of the human system towards the natural system, in calculating the risk, is brought under control. Vulnerability also becomes relatively larger due to the fact that wealth and value in cities increased. In that sense technology increases rather than decreases vulnerability.

According to the IPCC, vulnerability in relation to climate change can be described as 'the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes'.[682] The vulnerability of urban areas to climate change is equal to the risk that urban areas have in the long run through exposure to different climate factors and their sensitivity with respect to these factors. In this respect, vulnerability can be defined as a function of hazard (climate change), exposure, sensitivity and adaptability. Vulnerability is described not only in terms of the intrinsic properties of an urban system but also from the aspect of external threat of climate change and its capacity to adapt to changing conditions.

According to De Graaf (2009), concerning vulnerability of a system and the ability to deal with climate change, resilience can be determined by a

[682] IPCC, 2001

combination of four components: threshold capacity, coping capacity, recovery capacity and adaptive capacity.

- Threshold capacity is the ability of a society to build up a threshold to prevent damage.
- Coping capacity is the capacity of society to reduce damage in the event of a disruption that exceeds the damage threshold.
- The recovery capacity refers to the capacity of a society to recover to the same or an equivalent state that existed before the catastrophic event.
- Adaptive capacity is the capacity of a society to anticipate and be flexible towards uncertain future developments.

Using these four capacities can decrease vulnerability and increase resilience. Vulnerability expressed in the balance between the four capacities defined by De Graaf can be determined for each Phase in this investigation:

Table 7.3 Importance of the four capacities to reduce vulnerability in each Phase of the framework

Phase	Nature & defence	Anticipative	Offensive	Manipulative	Adaptive Manipulative
	AMPHIBIOUS CULTURE		LAND CULTURE		
year	-1500	1500-1800	1800-1890	1890-1990	1990-
Threshold capacity	Low	Low	Medium	High	High
Coping capacity	High	High	Medium	Low	Low
Recovery capacity	High	High	Medium	low	low
Adaptive capacity	High	High	High	Low	Medium

The first Phase of nature and defence is very high on coping, recovering and adaptive capacity since the attitude of adaptation does not stimulate threshold interventions. In the Anticipative Phase this has basically not changed even though more technology is used. With industrialization in the Offensive Phase the balance between the capacities change and due to the build up of wealth and the trust in technology the vulnerability becomes larger. The time of the Amphibious Culture holds a strong water and land relationship that means more adaptation and more anticipation, which makes people less vulnerable. This changed in the time of Land Culture when the natural contact with water (by transport and as part of discharge) disappears and the vulnerability is lowered with a high threshold capacity.

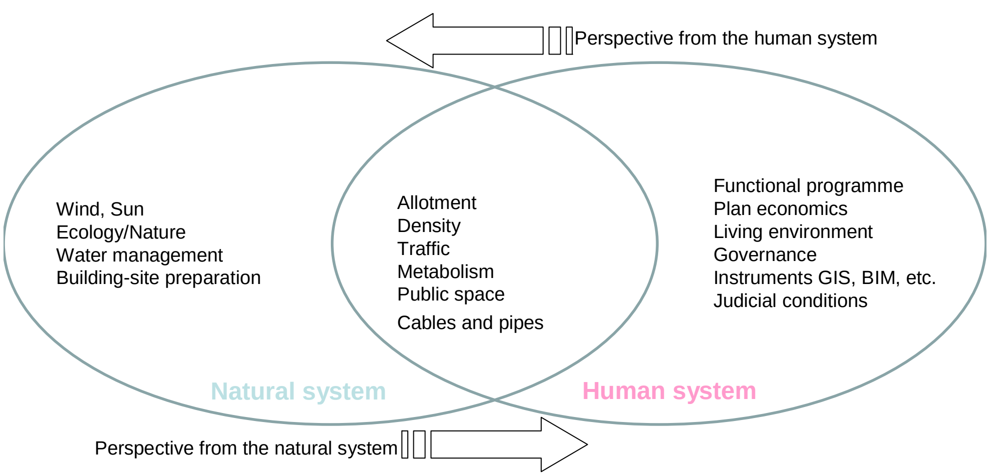
The attitude towards the natural system and, consequently, the importance of each of the four capacities are the basis of the third impact of the line of technology; its role as the controlling factor between the landscape and urban development. The available technology – and the way it is applied to enable urbanization – is crucial in what is used of the natural conditions, how much of the landscape is captured in the urban design.

The conclusion of the contextual group of features of the Systematic Analysis is that the main trend is the change of perspective from the natural to the cultural system. This change of attitude created by the growing possibilities of technology causes 1) technology to become increasingly refined on the one hand and to enforce continuous scale enlargement (in water management and urbanization) on the other; 2) a changing balance in the reduction of vulnerability; and 3) the controlling factor between landscape and urbanization. The technical interpretation of efficiency overtakes the interpretation of possibility within the given conditions of the natural system.

Disciplines

Second part of table 7.1 shows the disciplinary features of the Systematic Analysis. This paragraph focuses on the skills and the nature of the disciplines of civil engineering and urban design and not on the features, focus, city type, issues, urban strategy and organization. In general these features show great dependence on the context of societal and technological changes described in the paragraph above; they all move to an exhaustive organization, global trends, and multilayered, interdisciplinary practice of city development.

In an attempt to grasp what domain urban design has to supervise and what relation that has to the skills of the civil engineer the following scheme can be drawn:



This scheme shows the technical and aesthetic skills of urban design used to prepare the natural system for the human system in a sustainable way. There is tension between the natural and the human system because the natural system has a fairly stable system logic; some altering of the balance in the system is due to technological developments, while the human system has a continuously changing system logic, with rapid and drastic changes due to technical, economic and social influences.

The scheme shows how dependent the urban designer is on other disciplines. Urban design is principally the skill of having an overview and the capacity to make a combination of the technical, social and economic aspects of urban development. This capacity of a designing discipline is explored by Jannemarie de Jonge. She defined the relation of landscape architecture towards the political and scientific domains. *Landscape Architecture between Politics and Science* uses the conceptual model of Aristotle that defines three human capacities: to think (*theioria*), this is represented in science; to build (*poiesis*), represented in practical disciplines and arts; and to do (*praxis*), represented in ethics and politics. De Jonge views design as an intellectual activity that possesses two capacities: creative imagination and reflective assessment. These capacities enable the designer to connect the intellectual qualities of *theioria*, *poiesis* and *praxis* – respectively *episteme* (scientific knowledge), *techne* (skill) and *phronesis* (wisdom) – to each other. 'In the design process the skill of the builder meets the logic of the scientist and the practical wisdom of the leader.'[683]

The difference between the disciplines is all about language and mental concepts, for example both civil engineers and urban designers use the term design, while two very different activities are meant, each with their own logic and methodology. Also the scale of activities is of importance. The civil engineer is not only connected to the larger scale of the water system (sea, river and outlet waterway system) but also to the smaller scale of the water (storm water and groundwater) and the water chain (drinking water supply and sewer). In that sense the civil engineer can also be a stepping stone between scales like the urban designer. To end the division and bring the two worlds together things like language, concepts, methodologies and scales are of crucial importance. From different angles both the civil engineers and the urban designers contribute to this.[684]

The line drawn through the Phases connecting the features of the disciplinary side shows the development of organization, specialization and professionalization of the engineer – as the first formal professional to make cities – and urban design as a relatively young discipline in the twentieth century. The history of the practice of urban development reveals the change from working with 'urban principles' to an aesthetic design, working with a tactic to working with a strategy, working from small to large, working with hydrology to hydraulics, working from flexible to fixed, working from nature to working from culture and working integrally to staying within the domain.

The shift from being efficient in making polder cities to being efficient in producing the aesthetic and functional city ideal is perhaps most marked by the division between the disciplines. This division is literally the application of a layer of sand as the most effective method of building-site preparation and the disconnection between what it looks like and how it functions socially and economically – the domain of urban design – and how it is made given the natural conditions (the domain of civil engineering).

Spatial Interventions

The group of features that form the lines of spatial interventions are: coherence of the urban structure, relation to the territory, the water function, the relation between urbanism and water, building-site preparation and the urban model. When cutting across these features the spatial

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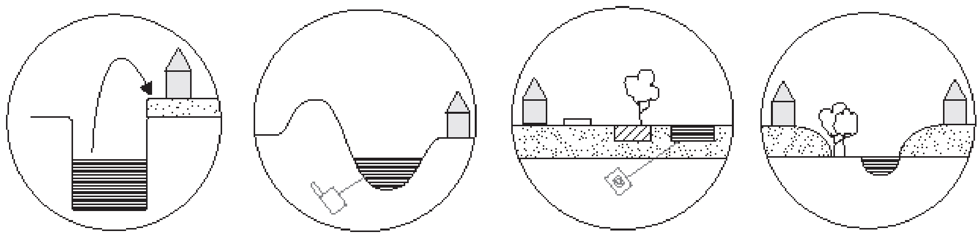
683 De Jonge 2008, VI
684 Calabrese 2004 also comes to this conclusion.

interventions that have great potential in relation to the natural system are: 1) the water and urban structure; 2) urban patterns; 3) groundwater and surface level; and 4) urban surface cover. These are spatial aspects that should be developed as a joint venture between the civil engineer and the urban designer.



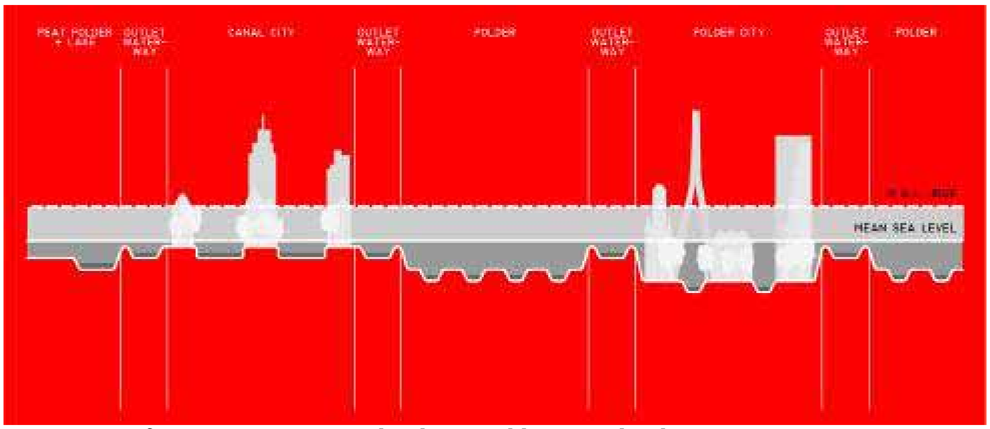
Picture 7.4 1) *Boezem* principle (digging a canal, filling in a building site, and mill), 2) polder principle (digging a *singel*, lowering the groundwater level with a steam engine), 3) *maakbaarheid* principle (hydraulic filling, drainage system and the induction of the electrical pumping station) and 4) partial principle (filling building and street locations, keeping landscape structure for greenery).
Source: Author, drawn by Stella Smienk

From the Systematic Analysis it becomes clear that the function of urban water and the development of urban structures, patterns, surface level and surface show a strong interrelation. The different functions of urban water (water, supply, storage, drainage, groundwater level control, waste water disposal [sewage], military, transport, representation, public space, recreation) and the fact that digging a canal provides material to fill in the building site are crucial in the design and the positioning of urban water. The function of the waterway is determined by public accessibility of the water, if it is steering or adapting to the urban structure and if it is separated or integrated in other systems. The water system can be part of the composition of the main structure of the urban design, or form a secondary or substructure in the city plan. Water can also be used to demarcate the city area.

Besides its position, the function of the water also determines the type of waterway (in cross section): canal or *singel,* gently winding watercourses accompanied by tree-lined avenues. These cross sections are defined by their original function, a stone quay (canal) has the function of transport and a *singel* is part of green public space and fortifications (as a moat).

Dike and groundwater system are the last elements of the water system that, although perhaps not as prominent, are influential in the urban tissue. In historical towns the dike is usually the centre, the dam, and can be recognized by differences in height or the name of a street: dam, *dijk* or Hoogstraat, meaning high street. Even more invisible is the groundwater system that creates the conditions for building-site preparation and in that sense is the most influential element of the hydrological cycle.

During the first Phases of natural and Defensive attitudes the surface water system and dikes are the main structuring elements for the position and growth of the settlements. Abrahamse shows how in the Anticipative Phase the digging of canals together with filling land for buildings is the basic urban principle, the *boezem* principle, for the early growth of the settlement that became Amsterdam. This urban principle is developed successfully into an 'urban concept' that became the famous ring of canals: *Grachtengordel*.[685] This 'urban concept' merges functionality and aesthetically in a main urban structure, with streets and houses along both sides of the canals. The urban pattern is formed by this main structure and in between the dimensions of the polder landscape are used as a master plan. A large part of the surface is water, with the groundwater level and the surface level in balance because the *boezem* principle is founded on this balance.



Picture 7.5 Left a city on *boezem* and right on polder water level.
Source: Author, drawn by Bart Schrijnen

The level of the groundwater and surface level is quite different from the polder principle that represents the Phase of the Offensive attitude to the natural system. Van Eesteren recognizes this in 1934:

> Everything is controlled by the level of filling: the layout of the waterway system, the water storage surface, the sluice system, and pumping stations. A city laid out as a boezem city must be designed differently than a polder city that lowered its groundwater table.[686]

The polder principle is applied in a town with a polder water level that is raised slightly (by about half a metre) and the groundwater level is lowered. This means that the water from the polder must be pumped into the *boezem*, to drain away naturally to a river, lake or the sea. This system requires a pumping station to be built, and more surface water is needed for water storage. The *Waterproject* is used in the Systematic Analysis as the example par excellence for the polder principle. Surface water offers the main green- and infrastructure of the new expansion of Rotterdam, connecting to the landscape structure, using the polder allotment as urban pattern, and giving the water a new function as green space in the form of the *singel*.
The next urban principle, *maakbaarheid*, comes into being at the end of the

[685] Abrahamse 2010, 334
[686] Van Eesteren 1934, 159

nineteenth century. Steam engines enlarge the scale of the landscape and in this new land the settlements are consciously situated:

> Residences on the new land, ideally orderly arranged in a ring of solidarity, inhabited by a hard-working autonomous population, ideally monitored by state-of-the-art steam-driven systems. This is the idea that caught on in the forties after the Haarlemmermeer is further uncovered (1839-1853). Perhaps the technological triumph, this domestication of the age-old water wolf in the centre of the Netherlands is the determining factor for conceptual broadening of the impolderment. Then the Dutch discover that space, even if this space had larger dimensions or is of a complicated type, could basically be manufactured in the name of society.[687]

Expansion plans required by the Housing Act of 1901 focus on railways, highways and industrial building, and the scale that these issues bring about is conveniently met by the new possibility of hydraulic filling. The significance of height differences (dikes, mounds, dams), dimensions of the buildings and open space (the urban pattern), the use of hydrological constructions (dikes, sluices, pumps) and the type of waterway (canal or *singel*) is replaced by urban programme and aesthetic design as the base for urban design.

Industrialization in the phenomena of the car, hydraulic filling and powerful pumps makes urban water lose its primary functions as drainage, storage and transport and it no longer serves as the main structuring element, nor influences the urban pattern. This principle of *maakbaarheid* has a layer of sand and an artificial water system of pipes and pumps. Here, with the changing climate, the problems of flooding and water pollution occur. Heavy rainstorms make the combined sewers overflow into the surface water system, ruining the water quality.

The urban surface cover as a spatial intervention comes into the picture. In urban areas five types of water are distinguished: storm water, drinking water, surface water, groundwater and waste water, and there are three sources: precipitation, drinking water supply and seepage. The discharge of rainwater is done through filtration, evaporation and storm water run-off in the surface water and the drainage system in the city: the sewer. In a normal urban tissue the balance between filtration, evaporation and run-off is respectively ± 40 per cent, ± 37 per cent and ± 23 per cent.[688] Due to the fact that this balance is dependent on the design and the conditions of the surface cover of the urban area, spatial intervention in the design of this cover has a strong influence on water management. Thus, the choice of the material of the surface of the urban tissue, in relation to green structures and storm water retention in/on buildings is an important spatial intervention for a solid water system.

The final urban principle, partial filling, is the result of the reintroduction of nature in the 1970s. The landscape structure, with the water system, remains available to form one of the main structures of urban

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[687] Van der Woud 1998, 263
[688] Palmboom 2010d, 39

expansion. In ‘cauliflower’ urban patterns (derived from the logic of infrastructure for slow traffic) the water system returns as a *singel* structure to emphasize the natural conditions. This use of water went on in the 1990s as a pleasant type of public space to divide private from public. The water is publicly accessible and functions as part of the backyard of the private houses.

The future urban principle will need to take the adaptive (storing water) and mitigating (storing energy) function of water and soil into account. Next to the role of water in the main urban structure, the incorporation of water dimensions in the urban pattern and the careful design of the urban surface cover; the most challenging will be finding a spatial expression of the relation of the groundwater and urban surface level in combination with other means of retention. Palmboom argues that spatial interventions should connect to the preparation of the natural conditions, the landscape and the ground and water systems for building (he calls it the ground surface) and not to ideological or aesthetic viewpoints. His publcition is therefore named Landscape Urbanism.

In the United Stated this term is more connected to planning, changing form organizing people to orgicizing space. In ‘The Landscape Urbanism’ Reader Charles Waldheim who is at the forefront of movement a collection of essays is assembled by many of the field's top practitioners. Fourteen essays written by leading figures across a range of disciplines and from around the world including James Corner, Linda Pollak, Alan Berger, Pierre B. Langer, Julia Czerniak, and more capture the origins, the contemporary milieu, and the aspirations of this relatively new field.[689]

James Corner argues for movement from aesthetic design to operational logic and from aesthetic categories to strategic instrumentality. He calls for a focus on the agency of landscape (how it works and what is does) rather than on its simple appearance. Since these activities belong to different domains a merging or crossing of the borders between technology (having the knowledge to understand the natural system and the implications of interventions) and urban design is needed.[690]

This closes the circle, connecting strongly to the seventeenth-century tradition of making a city. Cities were not ‘designed’ with an architectural end image in mind, but in making cities with the perfection of the skill, technique, the practice of surveying, the experience of water management and landscaping.

[689] Corner 2006
[690] Corner 1999, 4

Conclusions

The objective of this investigation has been achieved: a Systematic Urban Analysis of the development of polder cities and a critical evaluation of its development. The Systematic Analysis offers a body of knowledge that urban designers and civil engineers can use as a reference for the issues they are facing; the analyses and the urban archetypes representing the attitudes towards the natural system may also be used as a model for making cities water (and climate) proof. This analysis offers insight into successful and unsuccessful examples, in terms of how technological and spatial interventions can be resolved and how the perspective employed is of importance to their work.

The main question that prompted this investigation is: Is there a Fine Dutch Tradition in the urban context and if so, how can it be defined and how was, will and could the interaction between urbanism and engineering be influenced by it? A hypothetical answer is that the Fine Dutch Tradition (in the urban context) is an urban type that is based on coherence between hydrology and geoengineering (as the object of study of civil engineering) and the building of cities (urbanism). A new definition of the Fine Dutch Tradition in the urban context has yet to be specified. Together with the exploration of the first assumption of the hypothesis: civil engineering and urbanism developed in the same direction until the Industrial Revolution, and that the scale enlargement professionalized and divided the disciplines. This is followed by the second assumption that explores the Fine Dutch Tradition as being important to Dutch urbanism, even today, and can lead to improvement in building waterproof cities.

Urban Archetypes

The Systematic Analysis explains the cultural and technical progression of this urban archetype over Phases and the associated attitude towards the natural system. An "archetype" is an original model, an ideal example, or a prototype upon which others are copied, patterned, or emulated; an icon that is broadly recognized. The term 'urban archetype' is used to describe the physical "paradigm" emerging from each Phase. The paradigm is the concept wherein the social, economic and technical relationships that are geographically defined are brought together in urban form.

Five urban archetypes represent each Phase and show a particular links between technical possibilities, territorial conditions and the demands from the cultural system (economic, social). Territorial conditions remain more or less the same though time; climatic changes, like the small ice age from 1550 to 1750 and the current global warming alter the conditions, but not the underlying hydrological cycle.

Table 7.5 Urban archetypes of the attitude towards the natural system.

Urban archetype → Lines of meaning ↓	**Adaptive city** **- 1500**	**Fertile city** **1500 - 1800**	**Systemized city** **1800 – 1990**	**Maakbaarheid city** **1890 – 1990**	**Resilient city** **1990 -**
Urban model	Mound, dune, and river cities, Dike, dam, *burcht* and coast, cape, key cities	*Boezem* and fortification city	Polder city	Garden city Neighbourhood city 'Cauliflower'	?
Building-site preparation	Mound, dike	Surrounding canal, mud	Lowering groundwater table, sand	Integral hydraulic filling	Partial filling
Vulnerability	Individually	Collective	Probability	Risk approach	Individual and collective adaptability: resilience
Paradigm	Flexibility, acceptation	Cooperation, boldness	Organization, integration	Normailization, calculation and fixation	Flexibility, acceptation Cooperation, boldness Organization, integration
Relation to the physical geography	Time	Waterscape	Water level	Sand layer	Time, waterscape, water level
Organic Model by Lynch[691]	Logic of place	Water logic	Landscape	Social	Logic of place, water logic, landscape, social
Parctical Model by Lynch[692]	Height	Water and mud	Pump	Pipe	Height, water and mud, pump
technology	dike	mill	steam	Oil and electricity	Sun, wind and water

The Adaptive City as urban archetype is well balanced with the natural system and has a high mental and physical flexibility. It is an Organic Model since it stands close to the natural system (logic of place) and practical because it coincides with the rules of nature (using height as a condition for development). The lack of sophisticated technology is not experienced due to adaptation to the wet conditions and beneficial incorporation into the urban form. There is enough surface water to store, discharge and use the water effectively. Dry core and dike systems are integrated in the main urban structure and urban pattern.

The Fertile City represents concentration of people, wealth, power and knowledge in cities that profit from the hydrological advancements for business, for military defence and expanding wetland sanctuaries. The archetype of fertility is close to the Organic Model as far as hydrological system is concerned, but is practical in using water and mud as means of defence. Cooperation and boldness are the key factors to making the best use of the waterscape, and profit out of the physical geography. Vulnerability is more collectively organized and increasing, since through densification there is more property and population to protect. The dry core is expanded with strict control, placing the roots of the Dutch urban design tradition in this urban archetype. Strict control is expressed by connecting

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[691] The Parctical Model, or the city as a "machine", is "factual", "functional" and "cool", not in the least bit "magical" – as described by Lynch.

[692] The Organic Model, or the biological city, sees the city as alive rather than as a machine. It has a definite boundary and an optimum size, a cohesive, indivisible internal structure and a rhythmic behaviour that seeks, in the face of inevitable change, to maintain a balanced state.

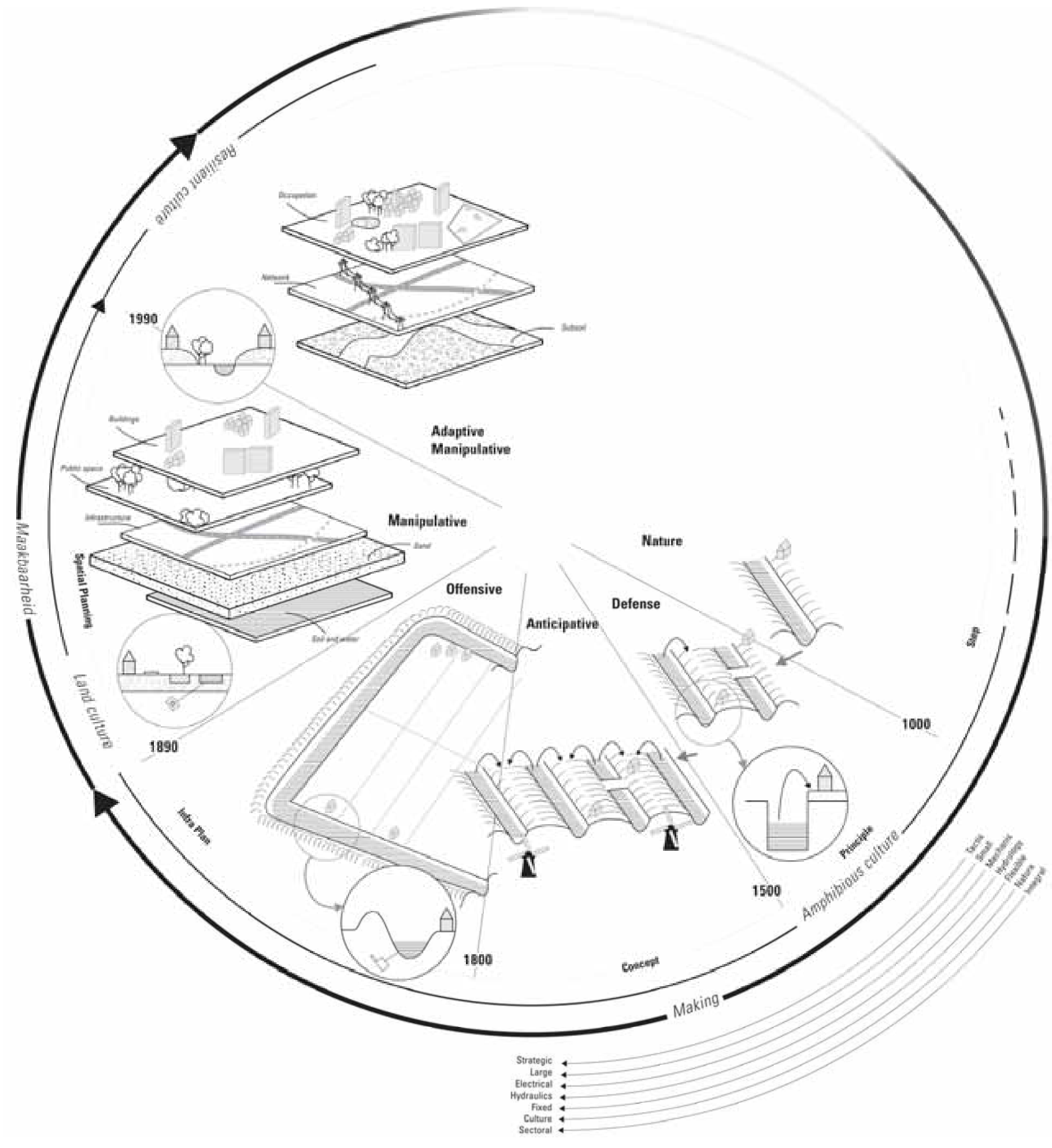
water and urban structure, the landscape (water) dimensions at the base of the urban patterns, the natural balance between groundwater level and surface level and an urban surface area that is half water.

The urban archetype of the Systemized City is characterized by the effects of industrialization: increased concentration, increased movements, increased power and increased wealth; and less hygiene, less social equity and less nature in the city. Water and urban main structure form the main infrastructure and the character of the landscape pattern due to drainage and ownership (Organic Model). By organization and integration, the urban water management shifts towards the Parctical Model (using pumps). Water and surface levels are also still part of the urban design but with a new scale enlargement brought about by the pump. Vulnerability is now organized around the probability of an event, making the cities better protected (less resilient).

The urban archetype of the *Maakbaarheid* City settles what started in the former Phase with the complete loss of characteristics of the landscape by covering it with a layer of sand, loss of the original water system as a structuring element (for the main structure and the urban pattern) to an artificial system of pipes, losing the capacity to of cope with, and recover from, floods and droughts. The paradigm of *maakbaarheid* completely relies on a technological threshold capacity. The Organic Model is lost and all odds are set on the Parctical Model, and through technology makes way for the *maakbaar*. Urbanism disconnects the relation between natural systems and urban form. It is reoriented towards social and economic needs represented through aesthetics.

The urban archetype of Adaptive Manipulation is under construction but can be defined as the 'work in progress of the safe, sustainable, healthy though vulnerable city': a city in balance with water and land, connecting all scales, with an individual and a collective adaptability and making use of all the high-potential features of the other urban archetypes: flexibility, adaption, cooperation, boldness, organization, integration, consciousness, time, waterscape, water level, logic of place, water logic, landscape, social, height, water and mud. In the future city themes such as energy and climate adaptation and mitigation become integral.

In the resilient City technology is used to reduce vulnerability to an acceptable level; and the residual risk is accepted and dealt with so as to limit personal risk. Information and monitoring technology allow for effective early warnings, real time control of the urban conditions – to anticipate expected conditions, urban design incorporate measures to strengthen the coping and recovering capacity and to improve the quality of the living environment.



Picture 7.6 Time and space: through the Phases from the first interventional step the principles *boezem*, polder, *maakbaarheid* and partial filling are developed. The tradition of making shifts into the *maakbaarheid* tradition; Amphibious Culture shifts into Land Culture and towards a Resilient Culture, hopefully.
Source: Author, drawn by Stella Smienk

Definition of the Urban Fine Dutch Tradition

The definition of the Fine Dutch Tradition from Steenbergen and Reh is: the Fine Dutch Tradition is that which is within the landscape; in other words that which is produced building on the territorial conditions. For urban areas this definition can be adopted but needs a 'however'. The Systematic Analysis shows that urban development is only possible when the territorial conditions are altered by the use of technology and spatial intervention (or maybe spatial technology like artificial dwelling mounds, dikes, waterways, and so forth). This is a human reaction to that which is within the landscape and has both a technical and a spatial component. Until the Industrial Revolution the reaction is steered by the perspective from the natural system (accepting, defending and anticipating this system) combining spatial interventions for water management and urbanization; after the 1850s the perspective shifts towards what is possible with technology, before considering spatial interventions. All natural 'flaws' are corrected with technology and the ultimate solution for the polder city is a layer of sand, a tabula rasa, in combination with an artificial water system. Warnings about the effect of this attitude on the natural system from Rachel Carson and the Club of Rome, and incidents like the oil crisis in the 1970s, provide incentive to shift back the perspective to the natural system.

For the definition of the Fine Dutch tradition the findings of other studies on which this research is built are very useful and can now be interpreted:

- The relation Van Eesteren finds between the water management and building-site preparation methods and the design of cities (*boezem* and polder city) is significant for the definition because it exposed the common ground between the hydrological and urban design.[693]
- The 'qualities of courage and tenacity, ingenuity and faith'[694] that Burke defines in *The making of Dutch Towns* is recognizable at all times; it even flipped the coin from the natural to the cultural perspective resulting in the *maakbaarheid* city.
- Van der Woud's conclusion that 'time and time again water management is an aspect of high importance that influenced the spatial order (on all scale levels)'[695] can be called the Fine Dutch Tradition.
- Frits Palmboom connects the physical geography and the water system more precisely to the concept of *longue durée*.[696] The *longue durée* in the Dutch territory is its hydrology and the characteristics of the wet and soft soil conditions, both captured in the Fine Dutch Tradition.
- The study by Abrahamse offers great insight into the development of the Fine Dutch Tradition showing that city development is focused on functionality, aesthetics and financial efficiency to deal with complicated population growth, landscape allotment, fortification system and water management conditions. According to Abrahamse

[693] Van Eesteren 1934, 159
[694] Burke 1956, 163
[695] Van der Woud 1987, 260-262
[696] Palmboom 2010, 37

the combination of water management and the soil conditions forced a – for the seventeenth century – large scale and prominently steered development.[697]

- Taverne argues that Amsterdam's builders did not intend it as an aesthetic design, but at developing a skill, a technique, a practice of surveying, the experience of water management and landscaping: The Fine Dutch Tradition. These traditional techniques are the basis of the form of the *Grachtengordel*. And, also according to Taverne, the basis of Simon Stevin's Ideal City is not a guideline for city expansions, but a contribution to the urban design method.[698]

Table 7.6 Accumulation of the Fine Dutch tradition per episode:

Episode One Natural and defence	· urban 'design' is the expression and the logical result of pragmatic (economic and social) and technical development with the difficult physical geographical circumstances · urban principles established (closed water soil balance – *boezem* city with dam and canals) · vulnerability was turned to profit · the dam; an urban artefact representing the technical, social and economic conditions
Episode two Anticipation	· represnted by a dry core, strict control and relation to the landscape · consciously planning on the basis of rationality, mutual consultation, and decision-making and the absence of any idealistic expression · efficiency · urban plan (building-site preparation – polder city) · urban engineering · technological advancement allowing use of bad soil. · technology of balancing water and land necessary to build a polder city · urban form is reflecting the necessity for social coherence, military placemens and the organization of public works to be able to realize these plans.
Episode three Offensive	· Natural system as master plan · urban engineer · urban integral plan (building-site preparation – polder 'pumped' city) · ability to control the water works and integrate them with other urban projects
Episode four Manipulation Machine power	· start of the disconnection of the urban design from the physical geography · division between the disciplines · urban infra plan (building site preparation and housing projects) · strict control becomes the Housing Law · scale increase in organization, technology

[697] Abrahamse 2010, 338-339
[698] Taverne 1990, 5

	· control of aesthetics
<u>Episode five</u> <u>Manipulation</u> <u>Man power</u>	· disconnection of the urban design from the physical geography · loss of identity of place · urban social plan on international ideas (building-site preparation = tabula rasa) · technocratic approach to efficiency
<u>Episode six</u> <u>Manipulation</u> <u>Flower power</u>	· reconnection of the urban design with the physical geography · search for identity of place · urban identity plan (building-site preparation and nature)
<u>Episode seven</u> <u>Adaptive manipulation</u>	· connection to the climate change projects · urban sustainable plan (building-site preparation and climate issue) · adaptability

In defining the Fine Dutch Tradition in terms of the urban context, the Systematic Analysis offers a simplified comparison of fundamental characteristics. The analysis confirms Mumford's argument that social behaviour determines history within the given conditions of the region. Treating water as a serious common threat results in a strong feeling of citizenship and thus creating a powerful tradition in water management and urbanization. These three features are revisited in the overview in table 7.5. Different episodes demonstrate that the Fine Dutch Tradition is a dynamic concept developing over through time. Traditionally the landscape is urbanized according to the the natural system and using concepts like: pragmatism, identity and logic of place, efficiency, urban planning, consciousness, cooperation, boldness and integration.

Finally, the definition of the Fine Dutch Tradition for the urban context can be formulated as follows:

> The Urban Fine Dutch Tradition is a dynamic tradition of making urban plans using the parameters of the natural system – linking in an efficient way the hydrological cycle, the soil and subsurface conditions, technology and urban development opportunities.

However, after the Industrial Revolution this perspective shifted to the Cultural System coming to full force in the post-war era (1945-1970) and reducing significance since the 1970s. Accelerating manpower particularly the post-war era, can be seen as a break in the tradition or even the absence of a Fine Dutch Tradition. But it is important to acknowledge that the capacity of *maakbaarheid* could develop only as a result of the Fine Dutch Tradition, because the build up of experience and the large body of knowledge of the natural system was then replaced by an artificial system.

According to Webber and Rittel and Lotte Stam-Beese it could be interpreted that the perspective swung to the Cultural System due to the concept of efficiency (the optimal relationship between means and end). But efficiency is an important characteristic of the Fine Dutch Tradition, too. Abrahamse showed how efficiency was part of the development of the *Grachtengordel*. From the contemporary point of view efficiency has no greater impact or embrace of new technologies than 300 years ago. This is an anachronism, considering the available means and the desired ends they were just as efficient in the seventeenth century as in the post-war era. Efficiency therefore is a dynamic concept that moves with the context. A more significant anachronistic difference between the seventeenth century and the post-war era, is the interpretation of the urban plan. The builders of Amsterdam did not aim at an aesthetic design for their urban plan, but at developing a skill, a technique, a practice of surveying, the experience of water management and landscaping: with the polder city the cumulative outcome. In other words the design of the city is the result of aggregate techniques for managing water and trade rather than an urban plan.

The *maakbaarheid* city introduces a completely different notion of city building. The design of the city, as a three dimensional aesthetic design, has absolutely no connection with the site characteristics: any aesthetic design is considered possible. According to Stam-Beese this technological influence brings about the end of unique urban design and urban design thereafter becomes uniform. It is the difference between working with what is possible considering the given conditions and working with an aesthetic design that will be made possible under any circumstance. Difference is in the tradition of making. Paradigms and the urban archetypes offer insight into the tradition of this making of Dutch polder cities.

When projecting the design of polder cities into the future, considerations about the available means and the desired ends are of importance: What is efficient? The concept of *maakbaarheid* turns out not to be efficient since its products, its cities, are unable to cope with the changing conditions of the hydrological system. The concept of efficiency has changed and today it means adapting to climate change in designing a flexible water system while mitigating by using the water for storage of energy.

The interpretation of the urban plan must also be reconsidered. Inspiration could be drawn from traditions including the urban principles of *boezem*, polder, *maakbaarheid* and partially considering the balance between land and water. A new principle based on the perspective of the natural system can efficiently create, coherence between the hydrological system, the soil and subsurface (the natural system) and urban development. This new urban principle can form the foundation for a new Dutch type of polder city and not merely aesthetic designs. Returning to the urban design as an exploration of means to come to the envisioned end can be considered 'research by design'.

Building-Site Preparation

It is no surprise that the history of building-site preparation has lapsed – even today it is not seen as a field of knowledge, practice takes it as it comes. Knowledge development, even if it is the comparison of experience in practice, should be undertaken for improving the quality of the product and to enable choices to be made on more solid bases. A greater coherence between urban design, building-site preparation and urban water management can be achieved by investigating the original landscape and water system. With this knowledge it will be possible to make a more refined balance between built (infra)structures, soil, subsurface and water.

The Systematic Analysis shows that the differences in building-site preparation have great influence on the urban design. The first approach to building-site preparation involved locating settlements on high and dry parts in the landscape and then building up these higher parts, the second was digging draining canals and using the mud to fill in the grounds, the third was lowering the groundwater level, the fourth was integral filling and the fifth method was partial filling of the grounds to obtain a sufficiently drained and flood-safe living area. The greater the knowledge about the exact effects of soil mechanics, groundwater flows, foundation piles and drains was developed the less spatial 'connectors' to the original water systems were used. The *Waterproject* (featured in chapter four) is an excellent example of the coalition between urban challenges and urban design on the basis of water management.

In the twentieth century, developments in technology and in the building industry touch on a variety of scales and processes. When housing becomes an industrial product, hydraulic filling prepares large sites for these buildings. Blijdorp is the first step, in post-war expansions including Ommoord and Zevenkamp the method is further refined. There is definitely a break visible in the line of development: the urban design becomes uniform on any type of soil conditions. Bakema's Mammoths for the Lage Land are an interesting example of a maverick style of the post-war era urban design, proving how extreme engineering captures the landscape in exchange for urban quality.

The method of partial filling in the 1970s, returns physical geography and identity to urban development. After the rationalization of the post-war era, identity became a great urban expressed by the return of water in historic centres since the 1970's. The strategy of 'urbanized landscape' developed by Frits Palmboom in the 1990s is a good example of the combination of identity and physical geography in a strategy for building-site preparation. He states that urban design should draw inspiration from the landscape because: 'This responds to the contemporary condition of the city in the widest sense of the word, as being extensive, layered and polysemous, dynamic and unruly, toed to its ground and never totally manageable by design.'[699] Urbanism continues to build upon landscape structures and processes, but gives them a twist if its own, for the purpose of making the landscape suitable for new, urban functions. Bernardo Secci called this 'il progetto del suolo' (the design of the ground layer) the spatial articulation of the site. Therefore the design of the subsoil guides the process of preparation for building.[700]

Different Phases of the Systematic Analysis show that the attitude towards the natural system represented by the use of – and the trust in – technology (structures and constructions), the relation to physical geography and the hydrological system is subject to a gradual change. The Systematic Analysis shows that urban design, the natural system (the landscape including the water system, soil and subsurface) and the available technology (use of structures, constructions and machines) together shape

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[699] Palmboom 2010, 41
[700] Secci 1989

the cities. Expression of the method of building-site preparation in the urban design (as visible in the urban principles of *boezem*, polder, *maakbaarheid* and partial sand layers) is connected to the attitude towards the natural system. In that sense, the relationship between the conditions of the territory and the available technology is instructional to urban design. When any aesthetic urban design is made possible through technology overlaying on any type of soil condition, not only the relation to the natural system is lost, but also the relation to technology itself. In this way the city was actually built, plays no influence in the urban design. Urban principles that did express the way the city was actually made, like the *boezem* and polder principle, where replaced by the technocratic *maakbaarheid* principle that focused solely on the aesthetic design.

Grachtengordel and *Waterproject* and their urban principles, respectively *boezem* and polder principle, show the connection between technology and the natural system. For future urban principles that should incorporate the adaptive and mitigating function of water and soil to climate change, the question that urban projects should start with is: What can be drawn from the natural system, what flaws can be solved by making use of the natural system and what needs to be solved by technology? A sustainable approach starts from the natural system.

This leads to the conclusion – use of technology implement consciously of the qualities of the environment and natural processes could lead to water cities that are more sustainable in function and character.

Civil Engineering and Urbanism

Part of the main question is: How was, will, would or should the interaction between urbanism and engineering be influenced by the Fine Dutch Tradition? Social aspects are an important part of the Fine Dutch Tradition expressed through concepts like pragmatism, cooperation, consciousness, boldness and integration. The first assumption connected to the main hypothesis states that civil engineering and urbanism develop in the same direction until the Industrial Revolution. Until then the disciplines were not divided but united, for example in one person such as Simon Stevin and Willem Nicolaas Rose both working from the perspective of the natural system.

In the seventeenth century the surveyor and military engineer use one and the same language in making cities. By the eighteenth century technical and aesthetical activities are defined on the building scale. On the scale of the urban project the division occurred in the nineteenth century, in the need to improve sanitation responsibilities become specialized; engineers turn to managing consumption/waste water while the field of urban design grows strength after the 1901 Dwelling Law focusing on urban expansion plans.

After the Industrial Revolution the disciplines are completely divided with much larger projects, more defined roles and professionalization: the perspective of what was demanded from the cultural system becomes leading. According to Webber and Rittel (1973) this enters all disciplines and scales due to the attraction to of efficiency: this becomes the guiding concept of civil engineering and consequently urbanism. Urban design thus pragmatically becomes devoted to economics of scale and efficiency - overlooking qualities of the site or society.[701]

Considering the fact that by the end of the nineteenth century the education of engineers and architects (as the forerunners of urban designers) splits, and that in the twentieth century the urban domain and the urban structure fall apart (in terms of infrastructure, building and public space), the first assumption can be validated.

The disciplines of civil engineering and urban design develop their own language and objectives and have a completely different approach towards the urban project; not only in their perspective but also the scale that is worked on. Civil engineering deals with the larger scale involving the water system (sea, river and outlet waterway system) and the smaller scale consisting of water (storm water and groundwater) and the water cycle (drinking water supply and sewerage). Soil mechanics is another field of knowledge that deals with local and regional scale processes. Urban design becomes an intermediary between the domains of infrastructure, buildings and public space connected to the regional scale as well as to the scale of the building block and all the scales in between. The skill of the urban designer is founded in the process of weighing conflicting requirements and reaching a compromise.

Future sustainable and climate proof water cities can be constructed on the basis of a collaboration of these two disciplines responsible for creating polder cities. The spatial interventions that should be worked on together are the water and urban structure, the urban pattern, the groundwater and surface level and the urban surface. This requires the connection of scales, the underground dimension by urban designers and for civil engineers to be aware of the spatial consequences of interventions in the natural. This could contribute to the next urban principle following the boezem, polder, *maakbaarheid* and partial principles.

The next urban principle of building-site preparation can reconnect water management and urbanization. The Fine Dutch Tradition could again become an interdisciplinary collaboration wherein both firstly understand the natural system and together decide on the spatial quality, technologically necessary and what 'spatial technology' can solve. Collaboration leads to a combined language, methods, concepts and integrated scales. Concepts like ecosystem services can play a role. A more generalist approach uniting knowledge through dialogue is necessary for sustainable development.

Is the Fine Dutch Tradition Sustainable and/or Climate proof?

With the unreliable character of the climate and the wilful behaviour of water, an innovative, less Manipulative and more adaptive attitude towards the natural system, sustainability, is vital. The Urban Fine Dutch Tradition is a dynamic tradition of making urban plans using the parameters of the natural system The Urban Fine Dutch Tradition is a dynamic tradition of making urban plans using the parameters of the natural system – linking in an efficient way the hydrological cycle, the soil and subsurface conditions, technology and urban development opportunities which by nature is

[701] Webber en Rittel 1973, 158

adaptive and climate proof. The importance of a dynamic water system for changing climatic conditions in the Netherlands is not just necessary for hydrological purposes; the water surface also works as a cooling element of to reduce the urban heat island effect and as a storage cell for renewable heat. The Fine Dutch Tradition is not a strategy (fighting against an undefinable threat) but a tactic (involving short-term moves for dealing with known conditions) whereby climate management is incorporated into day to day development, adapting to ongoing change while remaining flexible and anticipative of possible future changes.

Random urban development in the Netherlands is absolutely uncharacteristic. Planning and public enterprise is needed to build on wet and soft territory. Thus it is obvious that the Dutch have an old planning tradition that started in the Anticipative Phase (1500-1800). The paradigm and urban archetype of fertility is where the roots of the Dutch urban planning and design tradition are planted, defining the genius of cooperation, foresight, and balancing nature and culture. Spatial characteristics of the polder cities including; a dry core, strict control and relation to the landscape are all a combination of water management, geotechnology and urbanization. Strict control represents the fact that conscious interventions are made, characteristic of the tradition of urban planning and design in the Netherlands and even translated in the Dutch verb *polderen*: rationality, mutual consultation, and decision-making in a group. Aesthetics that are connected to the Fine Dutch Tradition are also rooted in the Anticipative Phase: the Dutch Renaissance, the representation of what was hydrological possible finds beauty in pragmatism and soberness and not in monumentality. This is still the basis of Dutch urban design and planning.

The seed that is planted in the Anticipative Phase giving form to the character of contemporary urban design and planning and also determines the projection into the future. In Nietsche's words, we can see what not to do. We must also keep in mind that human events ever resemble those of preceding times as stated by Machiavelli. The Fine Dutch Tradition hopefully offers the momentum for the development of climateproof water cities, which according to Mumford is needed to take a sufficiently bold leap into the future and find valid alternatives to build on and bring evolution to the tradition of making polder cities.

Terminology

- **Aanwas (NL)** a silted up part of the river close to the shore.
- **Ambachten (NL)** Polder boards
- **Boezem (NL)** Outlet waterway: the network of open water courses (and lakes) in a water management unit on a regional scale that serves as storage basin and drainage for the excess water from the polders and higher grounds.
- **Boezem town** Town with ground floor level on boezem water level.
- **Burcht (NL)** Castle, citadel, stronghold**.**
- **Combined sewer systems** Sewer for sewerage from the houses and for storm water discharge.
- **Cope system** Fan-shaped pattern of lots orientated from the river as primary reclamation basis.
- **Cunet (NL)** Method where the road or building is projected the soft soil is excavated and filled with sand.
- **Diking** Polder on the bottom of a large water body like the IJsselmeerpolders.
- **Drained lake** Lakes that are pumped dry to keep them form getting larger and for provision of agricultural land, like the Haarlemmermeerpolder.
- **Expansion plan** Urban Design plan to expand a city minimal on neighborhoud scale and considering the spatial impact of the desired functions.
- **Filling** Raising the ground floor level of wet and soft soil conditions with a layer of sand in order to create the desired freeboard and strengthen the soil conditions.
- **Freeboard** The height difference between the ground level and the groundwater level.
- **Geestgrond (NL)** firm ground comprising a combination of clay, peat and archaic sand dunes; suitable for building development.
- **Gezellig** Cosy and enjoyable
- ***Grachtengordel* (NL)** World famous and UNESCO heritage ring of canals around the Dam of Amsterdam.
- **Grachtenstad (NL)** Canal city
- **Hoogheemraadschappen (NL)/Water Authorities** water management units on a regional scale
- **Hydraulic filling** The layer of sand is applied by hydraulic pumping which is efficient for large scale building-site preparations.
- **Layout of the settlement** The set up of streets and buildings.
- **Maakbaarheid (NL)** The idea that man can make everything possible and control everything.
- **Mound/terp (NL)** Artificial dwelling hill that is used to flee on during floods in first instance and later were lived on.
- **N.A.P. Normaal Amsterdams peil (NL)** Amsterdam Mean Sea Level Amsterdam has received its name from the dam in the river Amstel, which dam served to keep the outer water from flooding the town.

To enable ships to enter the town a sluice was built, that was closed when the outer water reached a certain height level. This water level seems to be the origin of the Amsterdam height datum although it had at least no more than local meaning. The first indication that this datum was permanently marked dates from 1565 [5] but not earlier than 1674 a clear description about the character of one of these marks (a blue stone in the eastwing of the Haarlemmer dock) is mentioned [lol. After a storm and a very high tide in 1675 a set of new sluices were built in which marble stones were placed, provided with a groove and bearing the inscription: "Sea-bank's height, being 9 feet 5 inches above town datum".

- **Nature-friendly banks** Banks that offer room for flora and founa to enhance the biodiversity on the one hand and to improve water quality.
- **Passtukken (NL) Breaking zones** Zone where two landparceling systems come together and odd shaped land division system comes about.
- **Polder** Polders are a special type of drained agricultural land typically found in low-lying coastal areas, river plains, shallow lakes, lagoons and upland depressions. Before impoldering, polder areas were either waterlogged or temporarily or permanently under water. An area becomes a polder when it is separated from the surrounding hydrological regime in such a way that its water level can be controlled independently of its surrounding regime. This condition is accomplished by various combinations of drainage canals and dikes.
- **Polder town** Town with the ground floor level on polder level.
- **Polder waters** The network of open water courses in a polder; the area can have an urban or a rural land use.
- **R.P. Rotterdams Peil** Same concept as N.A.P. only for the Rotterdam situation 60 cm below N.A.P.
- **Randstad** Ring of cities around a grean heart in the western part of the Netherlands. Long kept as planning concept for this area.
- **Return water** Water that is used for hydraulic filling and is to be returned to the source.
- **Singel (NL)** Is a canal in a green structure without a stone quay.
- **Spuitkades (NL)** Dikes that are placed around the area that is to be filled in.
- **Stadsfabriek (NL)** City Factory where public works were designed and executed.
- **Superlevee** Mega dike concept coming from Japan.
- **Tame problem** The problem is clear and it is obvious when the problem is solved.
- **Terp (NL)** Articficial dwelling mound
- **Tocht** Draining ditch or canal.
- **Urban Design** Assembling the needs of society into a spatial plan considering the different functions of occupation, infrastructure, nature and
- **Urban surface waters** The network of open courses in an urban area (city, residential area) that serves as a storage basin and as drainage

for the precipitation on the urban area. Often, it also has other functions, for recreation, separation and design aesthetics.

- **Urban tissue** Ensemble of buildings, infrastructure and public space that for each era in the history of urban design is usually very typical (like the stamp ensembles of the 1950s and the cauliflower structures of the 1970s).
- **Urbanism** Broadly, urbanism is a focus on cities and urban areas, their geography, economies, politics, social characteristics, as well as the effects on, and caused by, the built environment.
- **Vroedschap (NL)** The Mayor and Executive Board of the municipal.
- **Wadi** Retention area in the form of a dry ditch covered in grass.
- **Waterstaatskaart (NL)** Map on which the polders, all the water works and the constructions are shown in colour. It is unique for the Netherlands; no other country has a Systematic series of maps showing the drainage of the whole country
- **Wicked Problem** The urban designer deals with open societal systems and therefore ‘wicked’ problems, which in contrast have no clarifying traits.
- **Woonerven (NL)** Home zones, dwelling area with houses along very slow traffic routes, pedestrian areas and squares.
- **Zoning plan** Plan that described the usage and/or building envelopes of an urban area.

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GAR Gemeente Archief Rotterdam (Municipal Archive Rotterdam)

- Publieke werken en Gemeente Werken (APWGW, Public Works)
- Stadsontwikkeling (SO, City Development)
- Oud Stadsarchief (OSA, Old City Archive)
- Photo Archive

AGW Archive Public Works Archief Gemeentewerken

NAi Netherlands Architecture Institute

- Lotte Stam Beese
- Van den Broek en Bakema

TUD Tresor University of Technology Delft Tresor

- *De Ingenieur* 1888-2008

De traditie van het maken: poldersteden - samenvatting

Introductie
(Hoofdstuk 1)

De dynamiek van het grote watersysteem van rivieren en zee en het regionale watersysteem van grond- en regenwater in samenhang met het oppervlaktewater is van cruciaal belang voor het proces van ontginning en verstedelijking in Nederland. De wijze waarop de verhouding tussen technische efficiëntie en de specifieke grilligheid van het grondgebied wordt vormgegeven, heeft zowel in Middeleeuwen en de tijd van de Republiek als aan het einde van de negentiende en begin van de twintigste eeuw de landschapsontwikkeling en de vorm van steden beheerst. Hoe, is steeds weer verschillend.

In de naoorlogse periode bedwingt men de grilligheid van het grondgebied met technische ingrepen en worden het landschap en de stad rationeel vormgegeven. De 'natuurlijke' condities van het terrein zijn dan ondergeschikt aan het maakbaarheidprincipe, waarbij een inflexibele techniek hoort. De negatieve effecten hiervan op het hydrologische systeem komen nu, met het veranderende klimaat, sterk naar voren. Meer en heftigere regenbuien, hogere temperaturen en droogte hebben vooral gevolgen voor het hydrologische systeem: rivieren stromen over of drogen op en steden worden door regenbuien overspoeld.

Het advies van de Deltacommissie 'Samen werken met water' dat op 3 september 2008 is gepresenteerd, bevat slechts één punt over de problematiek rondom regen- en grondwater. Punt 2: nieuwbouwplannen op fysisch ongunstige locaties baseren op kostenbaten afweging en kosten van locale besluiten niet afwentelen. Dit punt verwijst naar het probleem dat zich naast de rivier en de zee ook voordoet, het sneller vollopen van de laaggelegen polders van Holland. Het regionale watersysteem (van grond- en oppervlaktewater) komt hier onder druk te staan door frequentere, hevige regenbuien. Tegelijkertijd is de vraag naar stedelijke functies hier het meest urgent. Echter, in dichtbebouwde, verharde polders is maar weinig berging aanwezig en is hier tenminste kans op flinke waterschade. Naast het aanbrengen van oppervlaktewater wordt de inrichting van de waterhuishouding in een gebied bepaald door de methode van bouwrijp maken; dat kan zijn integraal-, partieel ophogen of ophogen met lichtgewicht materiaal, woonplatvormen, grondwater verlaging of zandbanen. Het bouwrijp maken bepaalt de mate van ophoging, het niveau van het grondwater, de benodigde pompcapaciteit en de hoeveelheid berging in het percentage oppervlakte water.

De verschillende manieren om in deze condities het landschap, als drager van het hydrologische systeem, in orde te maken en steden te bouwen, zijn tot nu toe nauwelijks systematisch onderzocht. De grootste lacune vormt het gebrek aan aandacht voor het onderwerp: 'hoe worden slappe en natte gronden bouwrijp gemaakt?', waarschijnlijk omdat dit proces altijd als zeer vanzelfsprekend wordt beschouwd. De enige publicatie over bouwrijp maken is van Segeren en Hengeveld (1984). In hun historische overzicht geven ze aan dat er veel onderzoek in het verschiet ligt.

Doel van dit onderzoek over “de traditie van het maken”, is te achterhalen wat de invloed van waterhuishouding is geweest op het stedebouwkundig ontwerp. Dat wil zeggen welke beslissingen binnen het denken en tekenen aan en over steden zijn beïnvloed door waterhuishoudkundige voorwaarden. Een veel gebruikt begrip ten aanzien van deze traditie is de Fine Dutch Tradition. Dit begrip is geïntroduceerd voor de landschapsarchitectuur door Steenbergen en Reh, op grond van typologisch onderzoek, maar wordt ook voor de stedebouw gehanteerd. Voor een goede eenduidige definitie ontbreekt echter vooralsnog het typologische en/of architectuurhistorische onderzoek als basis. Een dergelijk systematisch overzicht in de ontwikkelingen van de Nederlandse poldersteden kan leiden tot een preciezere definitie van de Fine Dutch Tradition. Deze definitie is cruciaal voor het inzicht in de relatie tussen stedenbouw en de civiele techniek in poldersteden. Nut en noodzaak van het onderzoek is vast te stellen waaruit deze traditie bestaat en te kunnen beoordelen of we daar in de toekomst iets aan hebben. Vanuit de traditie kunnen nieuwe scenario’s ontwikkeld worden die aansluiten bij de hedendaagse waterproblematiek.

De centrale probleemstelling van het onderzoek is de definiëring van het begrip Fine Dutch Tradition: hoe definieer je dat binnen de stedebouwkundige context en hoe werden/worden/zullen de stedebouw en de civiele techniek en hun interactie erdoor beïnvloed worden?

De hypothese die in dit onderzoek getoetst wordt is: de Fine Dutch Tradition (in de stedelijke context) is een vorm van verstedelijking die gebaseerd is op een grote samenhang tussen hydrologie en bodemcondities (als object van studie binnen de civiele techniek) en het bouwen van steden (het stedebouwkundig ontwerp). De eerste deelhypothese stelt dat tot aan de Industriële Revolutie er sprake was van een gestage ontwikkeling van de Fine Dutch Tradition. De schaalvergroting die de industriële revolutie teweegbracht, leidde tot een professionalisering van de disciplines van civiele techniek en stedebouw. Deze specialisering ontnam beide disciplines het zicht op het karakter van de Fine Dutch Tradition als interdisciplinaire katalysator. De tweede deelhypothese stelt dat de Fine Dutch Tradition bepalend is voor het vak stedebouw zoals wij dat in Nederland kennen en tot een kwaliteitsverbetering leidt.

Het onderzoek beweegt zich tussen de domeinen van geschiedenis, techniek en stedebouw en gebruikt methodisch een architectuurhistorische aanpak. In het architectuurhistorisch onderzoek worden alle aspecten van de gebouwde omgeving en haar productieproces toegelicht. De architectuurhistorische methode is een afgeleide van de kunsthistorische methode (literatuur- en archiefonderzoek, iconografie (beschrijving van het visuele)) met gebruik van zogenoemde archeologische methode (geologische, bodemkundige en historische kaarten en (lucht)foto’s) en de historisch kritische methode (inzicht geven in de historische processen, objectieve wetenschappelijke criteria, analyse en commentaar).

De doelstelling om een systematisch overzicht te maken heeft twee belangrijke consequenties voor het onderzoek. Ten eerste betekent het dat het onderzoek voor een groot deel op secundaire bronnen zal leunen omdat het om een zeer brede tijdspanne gaat. Bekende voorbeelden zullen daarom in een nieuw licht gesteld worden en echt nieuw archiefonderzoek zal beperkt blijven tot de cases vanaf de negentiende eeuw. Ten tweede betekent het wel dat er lange lijnen door de tijd getrokken kunnen worden. Om deze binnen een contex goed vorm te geven is Rotterdam als casus gekozen. Rotterdam is een interessante stad om de relatie tussen stedebouwkundig ontwerp en de natte omstandigheden van het grondgebied nader te bestuderen omdat het elke stedebouwkundige periode representeert en omdat er ten aanzien van de technische mogelijkheden veelal voorop gelopen is.

Om het grote tijdsbestek te kunnen overzien wordt de tijd opgedeeld in logische delen. De periodisering die in dit onderzoek is toegepast is gebaseerd op Van der Ham (2002) die onderscheidt de volgende perioden: natuurlijke, defensieve, offensieve en manipulatieve waterstaat. Deze periodisering is landschappelijk en waterstaatkundige georiënteerd. Op basis van literatuur uit het stedebouwkundige en historische domein is voor dit onderzoek een precisiering aangebracht die geleid heeft tot de volgende perioden die de houding ten aanzien van het natuurlijke systeem reflecteren: natuurlijk, (tot 1000), defensief (1000-1500), anticipatief (1500-1800), offensief (1800-1890), manipulatief (1890-1990) en adaptief manipulatief(1990 tot vandaag). Natuurlijk zijn adaptief en manipulatief tegengestelde begrippen, maar juist daardoor geeft de benaming aan dat het een periode is waarin wordt gezocht naar een aanpassing van de uitgangspunten in de ruimtelijke ordening.
Deze periodisering bepaalt ook de opzet van het onderzoek en de opdeling ervan in de hoofdstukken. Per hoofdstuk is eerst de algemene lijn van de stedebouwkundige ontwikkeling neergezet naast de lijn van techniekgeschiedenis, gericht op het bouwrijp maken. Vervolgens is per periode een casus in Rotterdam gekozen waarin de relatie expliciet wordt gemaakt.

Natuurlijke kracht en eenheid maakt macht (Hoofdstukken 2 en 3)

Tijdens de eerste twee perioden, natuurlijke (tot het jaar 1000) en defensieve houding ten aanzien van het natuurlijk systeem (1000-1500), is er sprake van acceptatie van de natte situatie, respectievelijk verdediging tegen het water. Tot aan 1000 regeert de natuur over cultuur en bestaat westelijk Nederland uit dikke lagen veen, vrij van dijken en doorsneden met meanderende rivieren en stroompjes. Daarna worden stukken veengebied in cultuur gebracht door sloten te graven die voor ontwatering zorgen en ook worden her en der dijken aangelegd om het gewonnen land en beginnende nederzettingen tegen het water te beschermen.

De eerste typen watersteden liggen hoog en droog, vlak bij water maar zonder directe relatie tot het water. Pas met de aanleg van dijken worden dijkdorpen en havenstadjes gebouwd waarin het water echt deel uitmaakt van de stadsplattegrond. De hoogte van de dijk is de belangrijkste voorwaarde voor stadsvorming in de polder. Door de ontwatering die het gevolg is van ontginning, was de polder ingeklonken en daardoor over de eeuwen kwetsbaar geworden voor overstromingen. De dam, als onderdeel van een dijk die een uitwaterend riviertje kruist, heeft een waterkerende functie maar regelt met een spuisluis tegelijkertijd de lozing van rivierwater op het open water. Het spuiwater wordt in combinatie met de getijdenbeweging handig ingezet om de haven op diepte te houden en de stad voor zeeschepen toegankelijk te maken. Op de dam werden goederen uit grotere schepen verladen op kleinere schepen of verhandeld. De dam werd zo een handelsplaats waarbij de buitendijkse monding als beschutte haven fungeerde. Damstad en polder waren zo niet alleen waterstaatkundig, maar ook economisch nauw met elkaar verbonden. Ruimtelijk kwam dat tot uitdrukking doordat aan de dam de sociaal economische functies gehuisvest werden.

In de zestiende eeuw wordt de molen op grote schaal toegepast bij het drooghouden van de polder, en dit gegeven markeert de omslag van de defensieve periode naar die van een anticipatie ten aanzien van het natuurlijk systeem. Deze wordt gekenmerkt door een proactieve houding ten aanzien van het water, waarbij gevaren op voorhand worden aangepakt. Tegelijkertijd staat de periode in het teken van eenheid. Maatschappelijke eenheid die resulteerde in de totstandkoming van de Republiek der Zeven Verenigde Nederlanden en eenheid in het gevecht tegen het water. Voor beide geldt ‘eendracht maakt macht’: de macht van een leger en vloot, de macht van dijkring en molen over het water, de macht van grootschaligheid: de schaalvergroting van stad naar staat, van de bescherming van een kavel naar die van een hele polder. De periode van 1500 tot 1800 is ook de tijd van de polderstad, die de letterlijke verbeelding is van Eenheid maakt macht.

De basis van poldersteden wordt gevormd door de basistypen watersteden uit de eerste twee perioden. Deze vormen de eerste ruimtelijke karakteristiek van de polderstad: de hoger gelegen ‘droge kern’ waar de nederzetting is begonnen, soms op een natuurlijke verhoging in het landschap zoals een donk, soms op een kunstmatig aangelegde dijk of dam. Voorspoed en groei leiden vervolgens tot uitbreidingen op de omliggende slappe grond, gewonnen uit het veen, of reeds in cultuur gebracht, maar nog niet geschikt om te bebouwen. Van de verschillende droge kernen waarop poldersteden in het veen zijn ontstaan, is de damstad de meest betekenisvolle. De manier waarop de bewoners langs de oevers van een veenstroom door de aanleg van een dam het water beheersen, grijpt vooruit op de veenpoldersteden.
De tweede ruimtelijke karakteristiek van poldersteden is de noodzaak tot ‘strikte beheersing’, die het gevolg is van de bewerkelijkheid van het bouwen van een polderstad. Ten eerste moet de grootte van de uitbreiding worden bepaald voor invulling van de behoefte van dat moment, en die van de eeuwen daarna. Ten tweede is een technisch plan noodzakelijk voor de afvoer en beheersing van het water en de handhaving van een constant peil in de stadsgrachten. In de meeste gevallen wordt begonnen met een omsingelende gracht, de singel, die door het nieuwe uitbreidingsgebied heen, door middel van dwarsgrachten, verbonden wordt met een reeks parallelgrachten. De singelgracht is in de eerste plaats bedoeld voor drainage van het nieuwe grondgebied, maar heeft tegelijkertijd in militair opzicht een defensieve functie en daarnaast een transportfunctie, waarbij pakhuizen worden ontsloten. Het overtollige water wordt afgevoerd en het waterpeil in het grachtensysteem gereguleerd met behulp van sluizen en windmolens. Vervolgens wordt het gewonnen land opgehoogd, verstevigd en bouwrijp gemaakt. Voor het ophogen gebruikt men de modder die door het graven van de grachten vrijkomt -het zogenoemde aanmodderen. In de bouwrijpe grond worden tot slot lange funderingspalen geslagen om de woningen in de diepliggende zandlagen te stabiliseren.

Na de ‘droge kern’ en ‘strikte beheersing’ is ‘grote betrokkenheid met de organisatie en het ontwerp van het polderlandschap’ het derde ruimtelijke kenmerk van de polderstad. Stadsuitbreiding in het veen wordt meestal over het bestaande agrarische patroon heen gebouwd, vaak met behoud van dat patroon.

De nieuwe kracht en accelererende krachten (Hoofdstukken 4, 5, 5a, 5b en 5c)

De periode van een offensieve houding ten aanzien van het natuurlijke systeem (1800-1890) start met de nieuwe kracht van de stoommachine. Het is het begin van een versnelling en een schaalvergroting die vandaag de dag nog steeds voortgaat. In maatschappelijk opzicht zorgde de stoommachine voor de groei van steden doordat de werkgelegenheid in de groeiende industrie en scheepvaart toenam, wat tot trek naar de stad, bevolkingstoename en uiteindelijk tot stadsuitbreiding leidde. Ook maakt de stoommachine het mogelijk in het watersysteem in te grijpen. Het water kan met grote kracht verplaatst en gecontroleerd worden. Verplaatsing van waterwegen, afsluiting van zeearmen kunstmatige verlaging en verhoging van de grondwaterstanden – dat alles was mogelijk geworden.

De basistypen watersteden met een polderuitbreiding uit de voorgaande perioden behielden hun karakteristieke stadsvorm tot ver in de negentiende eeuw. Na de Gouden Eeuw, waarin de meeste van deze uitbreidingen waren gerealiseerd, is er sprake van politiek verval en economische stagnatie en later de Franse overheersing. Deze neergang hield aan tot 1814, de totstandkoming van de het Koninkrijk der Nederlanden, maar pas na ongeveer 1850 komt er echt een einde aan de periode van stedebouwkundige stilte.

De eerste grootschalige negentiende-eeuwse stadsuitleg in Nederland is die van Rotterdam. Deze uitbreiding hing sterk samen met de noodzaak van een nieuw systeem van waterbeheer Doordat het water voor alles werd gebruikt en in de toch al overbevolkte landstad nauwelijks circuleerde, stonk het er verschrikkelijk en was de leefomgeving zeer ongezond. Stadsarchitect W.N. Rose ontwierp het Waterproject. Dit was in de eerste plaats een plan om het stadswater te spoelen zodat de kwaliteit ervan zou verbeteren. Ten tweede was stadsuitbreiding noodzakelijk; dit was in de omringende natte polder alleen mogelijk door verlaging van het grondwaterpeil. Landschapsarchitecten J.D. Zocher & L.D. Zocher verrijkten het plan in de derde plaats met een 'stadswandeling', en als laatste werd de aanleg van een woonmilieu voor de rijke burgerij toegevoegd. Deze vier verschillende stedelijke opgaven zijn op voorbeeldige wijze geïntegreerd in een ruimtelijk plan dat op de waterhuishoudkundige en bodemkundige toestand is gebaseerd.

Aan het eind van de negentiende eeuw kwam er door technische vooruitgang in combinatie met explosieve verstedelijking druk te staan op de poldersteden. De manipulatieve periode (1890-1990) wordt gemarkeerd door de komst van de verbrandingsmotor en elektriciteit. Dit heeft een enorme uitwerking op de stad en het watersysteem. De auto, de industrie en de geïndustrialiseerde bouw veroorzaken een andere ruimtelijke orde. Het watersysteem wordt steeds verfijnder bestudeerd en geregeld. Dit resulteert in een situatie waarin alles 'technisch' kan worden opgelost en er geen sprake meer is van een 'natuurlijke' aanpak van het watersysteem.

De aanleg van het rioolnetwerk en de drinkwaterleiding voert een scheiding in tussen systemen voor grondwaterpeilbeheersing, afvoer van afvalwater en toevoer van drinkwater. Een groot deel van het stedelijk watersysteem komt hierdoor ondergronds te liggen. Vanaf het einde van de negentiende eeuw wordt bovendien het verkeer en transport in de stad over water verdrongen door vervoer per trein, tram en auto. Dat leidt tot demping van tal van grachten en singels, met als gevolg een drastische vermindering van het oppervlaktewater. De waterstructuur van de polderstad blijft weliswaar van belang voor berging van water en ontwatering, maar wordt niet meer gebruikt als een element in het ruimtelijk ontwerp van de stad.

De mogelijkheid terrein integraal op te hogen door zand op te spuiten, komt op het juiste moment, precies wanneer de industriële werkwijze ook doordringt in de praktijk van stadsuitbreidingen. Blijdorp is hiervan een mooie illustratie. De Woningwet 1902 stelde als voorwaarde voor uitbreidingsplannen van gemeenten van meer dan twintigduizend inwoners dat er een stedebouwkundig plan aan vooraf moest gaan. Dat betekende een complicatie in de stadsontwikkeling. Het bleek zeer ingewikkeld om alle ontwikkelingsplannen van grondeigenaren op één stedebouwkundig plan te laten aansluiten. Het eerste uitbreidingsplan van Rotterdam (1906) na invoering van de Woningwet is dan ook eerder een gemeenschappelijke weergave van de plannen van de particuliere ontwikkelaars dan een op zichzelf staand uitbreidingsplan. Elf jaar later, na veel halsstarrig overleg met de grondeigenaren binnen het grondgebied van het inmiddels vernieuwde uitbreidingsplan Blijdorp, besloot het Rotterdamse stadsbestuur daarom om alle grond in het gebied te kopen en het zelf te ontwikkelen. Zo kon tegelijkertijd gebruik gemaakt worden van het voordeel dat ontstaat bij een grootschalige ontwikkeling, namelijk de mogelijkheid het gebied in één keer met zand op te spuiten. Het grootste voordeel daarvan is het gegeven dat door opspuiten het stedebouwkundig plan wordt losgekoppeld van bouwrijp maken. In feite worden bouwrijp maken en planvorming dan twee afzonderlijke fases die elkaar niet wederzijds beïnvloeden. Tijdens de eerste fase van de manipulatieve periode, de "accelererende machine kracht", is de technologie nog niet perfect en vanwege dit gebrek worden er nog steeds verbindingen gelegd met het natuurlijke systeem. In Blijdorp is dit het singelstelsel dat van het Waterproject verder gekoppeld wordt (hoofdstuk 5a).

In de tweede fase na de Tweede Wereldoorlog is met de toepassing van bijna geperfectioneerde technologie, "accelererende mankracht", de stedelijke schaalvergroting en vooral de ontkoppeling van het stedebouwkundig plan met de karakteristieken van het gegeven gebied een feit (hoofdstuk 5b). Daarin speelt het water geen rol meer; het is geen structurerend element bij stadsuitbreidingen. Dat past bij het geloof in de maakbaarheid van de samenleving met behulp van techniek en systematiek. Men wilde de maakbaarheid op gecontroleerde wijze bewerkstelligen in termen van sociale cohesie, sociale voorzieningen, controle op de stad en dus ook het watersysteem.

Lotte Stam Beese, Rotterdamse stedebouwkundige en verantwoordelijk voor de aanleg van Pendrecht, Lage Land en Ommoord, verwoordt zelf de invloed van de slechte grondcondities op de stedelijke uitbreiding en het effect dat integraal ophogen heeft op het stadsplan:

'Het falen begint eigenlijk al bij de situering van een woongebied. Wij hebben immers geen keuze meer om de meest geschikte plaats hiervoor te zoeken,...[....] Ten gevolge hiervan ontstaan in het kader van de noodzakelijke planning woongebieden vanuit een rationeel-theoretisch schema, evenals vroegere Romeinse legerkampen en missen het natuurlijk milieu, dat bij vroegere nederzettingen zo kenmerkend was voor hun vestiging: het beschutte dal, de rivierovergang of uitmonding, de aanwezigheid van water of de veiligheid van een bergtop. De aanwezigheid van deze gegevens en de innerlijke samenhang daarmee, leidde tot hun vormgeving en was kenmerkend voor hun verschijning. Het gaf deze nederzettingen en hun bewoners een identiteit. Het is dus niet zo vreemd dat hedendaagse woonsteden door hun rechtlijnigheid en gelijkvormigheid in bestemming veel gelijkenis vertonen met Romeinse legerkampen; ook zij hadden immers geen strukturele binding met de omgeving, zij waren op zichzelf staande onderkomen zonder meer, gekenmerkt door een eenzijdige bestemming. Ommoord wordt b.v. gebouwd op een slechtst mogelijke grondgesteldheid. Om überhaupt te kunnen bouwen moet het hele gebied door zandpalen bevestigd en draineerd worden, wat niet alleen een uitermate kostbare geschiedenis betekent maar ook een dwingende beperking bij de aanleg en uitvoering van alle mogelijke details. [...] Vele [...] dingen verliezen hierdoor het argeloze, prettige karakter en krijgen het aanzien van het nadrukkelijk gewilde, de hardheid van de technische doelmatigheid'.

De laatste fase van de manipulatieve periode is de accelererende flowerpower start in de jaren zeventig (hoofdstuk 5c). Op de naoorlogse periode wordt teruggekeken als een tijd van technocratie en kleinburgerlijkheid. Men wilde zich uit het sociale keurslijf van conventies bevrijden; daarnaast werd een zoektocht gestart naar de identiteit van de stad en aansluiting gemaakt bij de natuur. De publicatie in 1962 van Silent Spring waarin Rachel Carson de invloed van de mens op de natuur op biologisch niveau uiteenzet, had voor het eerst de ogen geopend voor de waarde van natuurlijke gegevens in de ordening van de ruimte. Het rapport 'De grenzen aan de groei' van De Club van Rome in 1972 en de oliecrisis van 1973 zorgden voor meer aandacht voor het verband tussen economische groei en de gevolgen hiervan voor het milieu. Zo kregen de natuur en ecologie een plaats binnen de ruimtelijke ordening en de landschapsarchitect werd hiermee een nieuwe speler in de stad; die het water weer gebruikt als ruimtelijk element in de stadsplanning wat leidde tot een nieuwe vorm van bouwrijp maken: partieel ophogen waarbij de bestaande landschapsstructuur een rol kreeg in de ruimtelijke opzet.

Adaptieve kracht
(Hoofdstuk 6)

De opmaat van accelererende flowerpower leidt in de jaren negentig tot de adaptief manipulatieve periode. Na twintig jaar krijgt deze nieuwe maatschappelijke en ruimtelijke tendens vaste voet aan de grond en ook in het beleid en vooral ook het bewustzijn van de burger (vooral de bijna overstromingen in de jaren negentig hebben dit in de hand gewerkt). Dit proces is nog steeds gaande: de wateropgave wordt via een status van *hot* *item* langzamerhand geïntegreerd in maatschappelijke structuren, bovendien speelt het een grote rol in de klimaatopgave.

Twee ruimtelijke nota's 'Nota Belvedère' (1999) en 'Anders omgaan met water, waterbeleid in de 21e eeuw in de stad' (2000) vormen de grondslag voor nieuwe ruimtelijke ontwikkelingen. Het toenemende belang van cultuurhistorie en waterbeheer in de ruimtelijke ordening komt meer en meer tot uiting, met de ontdemping van historische grachten, singels, havens en kanalen. (Herstelde) grachten en binnenhavens worden beschouwd als stimulans voor de lokale economie en vormen een meerwaarde voor het werk- en woonmilieu van middenstand en bewoners van een oud centrum. Bovendien komt tegelijkertijd de drievoudige waterdreiging van regenwater, zeewater en rivierwater aan de orde; steden die in een droge toekomst willen voorzien, zullen daarvoor een ruimtelijke oplossing moeten vinden.

In Rotterdam zijn Prinsenland en Nesselande voorbeelden van deze beweging richting waterproof bouwen. In Prinsenland wordt met de strategie van 'verstedelijkt landschap' dat wil zeggen met behoud van bestaande landschappelijke structuren, de nieuwe bebouwing ingepast. De al bestaande lintbebouwing wordt gehandhaafd en voor de verkaveling wordt dankbaar gebruik gemaakt van de landschappelijke condities. Hiermee worden bestaande occupatiepatronen en het natuurlijk systeem opgenomen in de planvorming. In Nesselande is het watersysteem een leidend principe en worden de hoogteverschillen die met het bouwrijp maken gerealiseerd worden, ingezet om de gewenste stedelijke kwaliteit te verkrijgen.
In de Rotterdamse 'stadsinbreiding' Park Zestienhoven is de wateropgave in een vroeg stadium opgenomen in de planvorming. Voor het bouwrijp maken is besloten voor integraal ophogen van de nieuwe woonbuurten, maar met behoud van de grote groenstructuren eromheen. Rudimenten van de voormalige polderstructuur zijn opgenomen in het nieuwe open water systeem dat alternerend met ondergrondse verbindingen een grof grid vormt. De keuze voor het integraal ophogen is ingegeven door de zeer slechte omstandigheden in het plangebied, het is er erg nat en slap met een zeer hoge kwel. Tijdens de uitwerking van het plan blijkt de ontworpen brede watergang die de eis van het Hoogheemraadschap van 10% oppervlaktewater inlost (financieel) onmogelijk vanwege de hoge kwel die het gebied teistert. Ondanks technisch en financieel onderzoek tijdens de planvorming komen deze problemen pas naar voren als er technisch diepgaande berekeningen worden gemaakt in de uitvoeringsfase. Bovendien is de locatie van de watergang deels gekozen op basis van de ontwerpmotieven, en niet alleen op basis van de techniek of grondcondities. Op historische kaarten zagen ontwerpers in de zone van de gedachte watergang roze vlekken en overhoeken van niet bruikbare plekken. Deze structuur is toepasbaar door de oude watergang te laten liggen en er een nieuwe naast te leggen waardoor er eilanden ontstaan met een geheel eigen milieu. De logica van deze vormgeving is gebaseerd op de regels van het water, de hydrologie, een constant gegeven dat net als de karakteristieken van het grondgebied de condities voor grondgebruik vormt.

De kracht van een traditie (Hoofdstuk 7)

Het doel van dit onderzoek is het maken van een systematisch overzicht van de ontwikkeling van polder steden. Nu dit is afgerond kunnen binnen dit overzicht lange lijnen van betekenis en impact bekeken worden. De eerste conclusie en punt van analyse is dat het opzetten van een periodisering op basis van de technische mogelijkheden en de houding ten aanzien van het natuurlijk systeem een dankbare en zinvolle onderneming is geweest. Het brengt inzicht in de evaluerende coherentie per periode en zorgt er voor dat er vergelijkbare aspecten naast elkaar gezet kunnen worden. In tabel 7.1 zijn deze uiteengezet, met een verdere uitwerking van de manipulatieve periode in tabel 7.2.

Voor de analyse zijn de aspecten gegroepeerd in drie categorieën: context, disciplinair en ruimtelijke ingegrepen. Per categorie zijn de lange lijnen bekeken.
De conclusie van de contextuele kant van het systematische overzicht is dat de Industriële Revolutie een belangrijke verdraaiing van het perspectief heeft veroorzaakt. Sinds technisch alles mogelijk is speelt het natuurlijke systeem geen conditionele rol meer in de ruimtelijke ontwikkeling maar wordt vanuit het culturele perspectief gehandeld om een gewenst programma te realiseren. De toenemende technische mogelijkheden veroorzaakt dat: 1) de technologie is steeds meer verfijnd aan de ene kant en anderzijds zorgt voor een continue schaalvergroting (in water management en verstedelijking), 2) dat technologie voor een veranderende balans in het terugbrengen van de kwetsbaarheid zorgt en 3) dat technologie het controlerende element tussen het natuurlijke en cultuurlijke systeem is.

De disciplinaire lijn door de verschillende perioden heen representeert groei van organisatie, specialisatie, professionalisering van de civiel ingenieur (als eerste formele professional die steden maakt) en ook van de stedebouwer als een relatief jonge discipline in de twintigste eeuw. De geschiedenis laat zien hoe het maken van de stad met behulp van stedelijke principes wordt vervangen door een esthetisch plan, hoe het tactisch werken verschuift naar strategie, hoe het van klein heel groot wordt, hoe hydrologisch wordt vervangen door hydraulisch, hoe van flexibel er met vaste systemen wordt gewerkt, en hoe de natuur vervangen wordt voor cultuur en integraal naar sectoraal gewerkt wordt.

Belangrijk hierin is de verschuiving van efficiënt zijn in het maken van steden gegeven de condities naar het efficiënt zijn in het produceren van een esthetisch en functioneel stedelijk ideaal dat geen relatie heeft met "het maken". Dit markeert het meest prominent de segregatie tussen de disciplines van civiel ingenieur en stedebouwkundige die ruimtelijk tot uitdrukking komt in de zandlaag als meest effectieve manier van bouwrijp maken.

De lijn van ruimtelijke ingrepen wordt samengesteld uit de aspecten: coherentie in de stedelijke structuur, relatie tot de natuurlijke condities, de functie van het water, de relatie tussen stedebouw en het water, bouwrijp maken en het stedelijk model. De doorsnede van deze aspecten levert de meeste potentiële ruimtelijke ingrepen op waarin de technische en ruimtelijke perspectieven samen kunnen komen: 1) het water in de stedelijke structuur, 2) stedelijke patronen, 3) grondwater en maaiveld niveau, en 4) het stedelijk oppervlak. De principes vanuit het systematische overzicht die deze interdisciplinaire onderneming kunnen ondersteunen zijn: het boezem principe (gesloten grondbalans en "natuurlijke" afwatering), het polder principe (aanleggen van singels in combinatie met grondwater verlaging en pompen), het maakbaarheidsprincipe (een zandlaag aanbrengen met een drainage systeem en pompen) en het partiële principe (ophogen van gebouwen en straten en de originele landschapstructuur behouden voor de groenstructuur).

De logica die uit het systematisch overzicht naar voren komt, is preciezer gedefinieerd in de lange lijnen van betekenis en impact en vertaald naar stedelijke archetypen:

- De adaptieve stad: in balans met het natuurlijke systeem, flexibel ruimtelijk en mentaal;
- De vruchtbare stad: de hydrologie gebruiken voor de stedelijke opzet, coöperatie en durf;
- De gesystematiseerde stad: integrale aanpak van toenemende concentratie, beweging, kracht, welvaart, en afnemende duurzaamheid;
- De maakbare stad: geen verbinding met het natuurlijk systeem en het water;
- De adaptief manipulatieve stad: "werk in uitvoering naar een veilige, duurzame, gezonde en kwetsbare stad".

Tenslotte, levert dit onderzoek de definitie van de Fine Dutch Tradition in de stedelijke context: *De stedelijke Fine Dutch Tradition is een dynamische traditie in het maken van stedelijke plannen vanuit het perspectief van het natuurlijke systeem om, op een efficiënte wijze, een grote coherentie tussen het natuurlijke systeem – de hydrologie en grondcondities – en stedelijke ontwikkeling te verkrijgen.* Echter, na de Industriële Revolutie is het perspectief gedraaid naar het cultuurlijke systeem en dat heeft in de naoorlogse periode een enorme vlucht genomen. Dit zou als een breuk in de traditie kunnen worden beschouwd, maar het is belangrijk om te herkennen en erkennen dat deze vlucht, de maakbaarheid, zonder de voorgaande traditie niet had plaatsgevonden omdat hier een grote rijkdom aan ervaring en kennis voor nodig is.

Het nieuwe principe voor de klimaatbestendige, duurzame stad zal door de vereende disciplines civiele techniek en stedebouw gemaakt moeten worden. De Fine Dutch Tradition kan weer een interdisciplinaire katalysator zijn waarin het natuurlijke systeem als uitgangspunt een verbindende schakel vormt. De eerste stap is het nemen van de gezamenlijke beslissing van wat de ruimtelijke kwaliteit kan zijn van het natuurlijk systeem, wat met behulp van dit systeem gemaakt kan worden en wat technisch nodig is. Deze integrale manier van werken kan leiden tot een gezamenlijke taal, concepten en methoden op een integraal schaalniveau en tot een duurzaam, klimaatbestendig resultaat.

The tradition of making: polder cities - summary

Introduction
(Chapter 1)

"God created the world, but the Dutch created Holland". The Dutch have a rich and world-renowned 'fine tradition' involving an indissoluble relationship between urban development and civil engineering. Expertise and knowledge of hydrology and water-related technology have allowed productive land to be carved out of swamp and water: creating what is known as the polder.

Managing the regional water system, which consists of the dynamics between groundwater, rainwater and surface water, is crucial for the development and urbanisation of the polders. In this way Dutch cities are hydrological constructions, with a spatial layout that is strongly connected to the division of land and water. The relation between technical efficiency and the specific characteristics of the territory results in the design of cities and landscapes, with approaches evolving over time.

However, in the post-war era the characteristics of the natural territorial systems are neglected through the use of modern industrial technology that favours man made environments – known in Dutch as the *Maakbaarheid* (man-made) principle. This develops a sentiment in which technology can resolve anything, but it has become clear this system is very inflexible and relies on consistent conditions. Recent weather events together with climate change forecasts are placing pressure on the hydrological system – technology yet again will need to be revised. More frequent and intense storm events, higher temperatures and dry periods challenge these hydrological systems: rivers flood or run dry, cities flood and the pumping makes them subside. Rotterdam has been forced to take these climate challenges seriously, exploring options and now appointing a climate director. A coordinated strategy is necessary for professions responsible for building on wet and soft soil, balancing out land and water: civil engineering and urban design.

Until now, landscape and hydrological systems have not been consciously studied as foundation for urbanism in the Netherlands. This issue has been neglected and disregarded possibly because building-site preparation is such a ubiquitous activity in Dutch urbanism. Only one publication is available, by Segeren and Hengeveld (1984) which also states that a lot research is still to be done. The most important reference to Dutch water cities has been documented by Gerald L. Burke, *The making of Dutch Towns* (1956) which categorises the typology of water cities, but unfortunately the research does not extend beyond the eighteenth century.

As said, an exhaustive study into the hydrology and the physical geography of the territory and its relationship to the construction of Dutch cities has not yet been conducted.
The objective of this research is to provide a systematic urban analysis of the development of polder cities. This will involve exploring 'red thread' -

the continuity and fundamental characteristics - that gives the Fine Dutch Tradition meaning and impact within the urban context. This research aims to define a foundation upon which to prepare Dutch cities for new environmental and climate challenges. The problem statement for this study is formulated as follows: *Is there a Fine Dutch Tradition in urban design and planning and if so, how can it be defined and how is, is and could the interaction between urbanism and engineering be influenced by it.*

This study investigates the development of polder cities, using Rotterdam as the main case study. The technology associated with building-site preparation, as a method for dealing with building on a wet and soft soil, is crucial for building polder cities. The research covers examples across the Netherlands but shall focus around Rotterdam, as it is an example of city that provides a living narrative of the technical evolution of Dutch water systems and a site that is overtly exposed to changing climatic conditions.

The hypothesis that guides this study is as follows: The Fine Dutch Tradition (in urban design and planning) is a type of dealing with urbanization that is based on a large coherence between the hydrological system, the soil conditions (as the objects of study of civil engineering) and the building of cities (urbanism).

The first assumption of this hypothesis is that civil engineering and urbanism developed hand in hand until the Industrial Revolution. The expansion in scale introduced by the Industrial Revolution leads to the disciplines of civil engineering and urbanism becoming professional and more specialised. This new specialization divides the disciplines, creating a wedge in the Fine Dutch Tradition that separates urban from water.

The second assumption is that the Fine Dutch Tradition is an essential foundation for Dutch urbanism, as much today as it will be tomorrow. It can lead to improvement in building form/character, water resistance and climate-resilience in cities. The current debate in the transition from industrial to a post-industrial city is (again) focused on aesthetics. This discussion must re-incorporate a relationship with water, as this study shall identify.

The research moves between the domains of history, technology and urbanism. The research method is thus based on an architectural historian approach. This method is based on art history (literature, archives and iconography), archaeology (maps and pictures) and the historical/critical method (insight in historical processes, objective scientific criteria, analyses and comments).

There are two issues associated with the historical analysis, as referred to in table 1.1. Firstly, research can only make use of primary sources up until a certain point and thereafter will depend on examples that have been studied for other purposes. The importance of making a systematic analysis has been chosen rather than developing brand-new material. Second, it will be possible with a systematic analysis to demonstrate the evolution of the Dutch approach. It results in finding the red thread in the story of the Fine Dutch Tradition and its meaning and impact in the urban context

A systematic analysis of polder cities can only be based on an interpretation of time to show the different development status of the Fine Dutch tradition.

These phases represent distinct stages of development and attitudes. Phases are of course indicative and may have shorter or larger transition times between them and depending on location. This study is structured according to a framework that is constructed on the work of Van der Ham (2002) and other literature, which identify phases that represent the attitude towards the natural system:

Part One: Amphibious Culture (Adaptive attitude)
I.Natural and Defensive Attitude: Natural Power -1500
II.Anticipative Attitude: The Power of Unity 1500-1800

Part Two: Land Culture (Manipulative attitude)
III.Offensive Attitude: The New Power 1800-1890
IV.Manipulative Attitude: Accelerating Powers 1890-1990
V.Adaptive Manipulation Attitude: Adaptive Power 1990-

The chapters are ordered according the phases in time and start each with the introduction of the general urban development, technology and the city builder's professional background. After outlining the general developments and characteristics of each time period, a case study site in Rotterdam is used for that specific time and development showing how the territorial and technical conditions may have influenced urban design. The connection to other projects in the Netherlands of that time period and the more general developments of building-site preparation have been inserted into the story about Rotterdam. The projects will be evaluated based on their current performance within Rotterdam's hydrologic system using the information noted in the Waterplan 2 (2007).

In conclusion each chapter describes episodes of the Fine Dutch Tradition associated with that specific phase. During the Manipulative Phase three urban types are distinguished with a very particular urban typology in relation to the available technology breaking this phase into three chapters; 51, 5b and 5c. This results in more episodes to the Fine Dutch Tradition than there are phases in the attitude towards the natural system.

Natural power and power of unity (Chapters 2 and 3)

Until the eighth century, the Dutch lowlands are an uninhabitable marsh where the forces of water and wind have free reign. The inhabitants accept these conditions, adopting ways to live with it. There are small initiatives for controlling the landscape such as digging ditches and draining fields to grow crops.

The Defensive Phase, from the eleventh to the sixteenth century, involved the large-scale introduction of the mill - a time also referred to as the 'great reclamation' of agricultural lands. The ditches that are dug around separately owned lots discharg into rivers, creating regular patterns and standard measures in the landscape. In the twelfth century this discharge becomes difficult partly due to salination of the main river, the Rhine. Inhabitants interven by digging new discharge canals and by building dams and sluices to control the water. The cooperation and organisation of these kinds of projects leads to one of the oldest known democracy, the ‘water boards’.

The first stages of development in what is now known as the Netherlands focus on the higher grounds, including the dunes and sediment river-beds. Later development moves to the artificial dwelling mounds, dikes and *burcht*s. These elevated places are situated along the dune coast and rivers. Living on mounds is a common practice mainly in the north of Netherlands, around Groningen and Friesland. While building on *burcht*s focuses along the central and southern coastal regions around Holland and Zeeland. The first water towns are built on higher - possibly artificially raised - grounds referred to as the *geestgrond*, mound, river, coastal, *burcht*, dike and dam towns. The expansions of these towns are usually of a military nature, with fortifications and buildings inside polders – known as the polder towns.

Although the obvious function of the dike is to protect dwellings in the low land behind, most settlements are also built on the dike. Buildings directly against or on the dike are better protected against flooding and have direct access to a trade route. This ribbon development is also the basis for urbanisation and still exists as a settlement form.

When a dam is constructed in a dike village at the point where a peat stream flows into larger water, it becomes a dam town, such as Amsterdam and Rotterdam. The dike at these points is the most important condition for the creation of towns in the polders, because soil compaction and subsidence make these areas vulnerable to flooding. The dam has a water defence function, but with a drainage sluice it also takes care of discharging river water into open water. A combination of the scouring effect of the sluice water and the tidal movement are cleverly used to maintain the harbour at the correct depth and makes the town accessible for seagoing ships. The economic significance of transport over water from sea to the hinterland and vice versa is embodied in the dam with drainage sluice, which becomes the heart of the city. The drainage sluice is able to accommodate only relatively small ships, and the cargo from larger ships had to be transferred or traded on the dam. The dam becomes a market, and the peat river estuary outside the dike a sheltered harbour. The dam town and the polder are therefore bound closely together, not only hydrological but also economical. This is manifest in a spatial sense by building the central social functions, such as the weigh house, the town hall and the church, on the dam.

The technology that marks the transformation to the next phase is the windmill, coming into larger scale use at the turn of the sixteenth century. This phase is characterized by a new, pro-active, attitude towards the water: people start to develop technologies to control the water management conditions however taking advantage of locally available resources. With this new mechanism larger volumes of water could be moved providing a more effective and safer system to keep regions and cities dry. The availability of the new hydrological instruments, besides the mill also sluices and dams are built, changes the approach towards the water from Defensive to Anticipative: The power of unity.

A first step in social unity is underpinned by the establishment of the Republic of the Seven United Provinces at the Union of Utrecht (1568) including a united army. Under these conditions knowledge of wet and soft soils is developed. The power of unity represents a new functional scale including society, city and water system. The water protection of a plot grows into water protection of a polder. The Anticipative Phase gives rise to the polder city, the literal representation of the power of unity.

The settlements of the two first phases, mound, river, coast, *burcht*, *geestgrond*, dike, and dam towns, form the first important characteristic of the polder city: the higher and levelled 'dry core' on which the settlements start. Prosperity and growth leads to expansion of the surrounding wet soil, derived from peat or already prepared for cultivation, but not yet prepared to be built upon. Of the various dry cores on which the peat polder cities are developed, the dam town is the most meaningful. One could say that dike residents, who live alongside a peat bog and controlled the water by building a dam together, are conceptually ahead of the peat polder cities. This is where the second important spatial characteristic can be seen: the need for 'strict control' as the result of the cautiousness with which an expansion of the polder city needs to be realised. First, the size of the expansion of the urbanisation needs to be determined, which had to comply with the requirements of that time but also for centuries to come. The second aspect is a technical plan in order to ensure that water can be discharged and controlled, and that the water in city canals will stay at a constant level. In most cases the start is initiated by building an enclosing outer canal, which is connected through the expansion area by means of a sequence of parallel canals. The outer canal is primarily built for drainage, but also has a military or defensive function and a transport function (access to warehouses). By means of sluices and windmills the water level of the canal system is regulated and the excess water discharged. Then, the reclaimed land needs to be raised in order to obtain the required protection level, and it has to be consolidated and prepared for building. Mud excavated from the canals is used for raising the level, and is supplemented by soil which often needs to be transported from far away. Long foundation piles are driven into the ground in order to stabilise the housing in the deep-set stratum of sand.

After the dry core and the strict control the string connection to the landscape that is used as a master plan for urbanization is the third spatial characteristic for a polder city.

The new power and accelerating powers (Chapters 4, 5, 5a, 5b and 5c)

The new power of the steam engine triggers the 'Offensive Phase'. Early industrialisation turns cities into places where people concentrate around jobs in factories and harbours that grows and grew. The social and functional change of cities during this period cannot be underestimated, with significant internal migration to the cities leads to cramped and impoverished conditions. Industrialisation ignited an accelerated scale of development, which in form and practice is ongoing.

After the previous phases, Defence and Anticipation, new fossil fuel energy technologies make it possible to intervene in the water system. Water can be moved with greater power and far greater precision allowing for greater levels of perceived stability. Construction of channels, closing of sea arms and artificially lowering or raising ground water levels: everything seems possible.

The character and layout of the principal water city types that are developed with a polder city in the prior phases are preserved far into the nineteenth century. After the Golden Century, when most of these expansion projects are built, the Republic suffers from political decay and economic stagnation and later invasion from France. This downward development ends in 1814 when the monarchy is instated however urban development recommenced only after 1850.

The first large scale city development in the Netherlands is the expansion of Rotterdam with the 'Waterproject' plan, designed by military engineer and city architect W.N. Rose (1801-1877). This development is associated with a citywide water management project after stagnant polluted inner city water network leads to a cholera epidemic. Rose's proposal involves an independent water system for the city (separate from the country side where the water management has very different aims). With collaboration from landscape architects J.D. and L.P. Zocher, the Waterproject is ingeniously designed by combining preparation of the surrounding wet and soft polders within the new water management system thus creating an integrated urban design strategy.

The Waterproject's first aim is to flush the waters in the inner city to improve quality water. The second aim is to address the desperately needed city expansion. The dramatic expansion of Rotterdam's ports during the nineteenth century attracts many new residents. Lowering groundwater levels in the polders is the only suitable solution for expanding residential areas. To make the project socially profitable, Rose asks the Zochers to develop a plan with a public park compensated by living quarters for the rich. Through this plan, most of the city's serious challenges are addressed while integrating characteristics of the territory and the available technology within an urban design.

At the end of the nineteenth century, explosive urbanisation and technological prosperity puts pressure on the polder cities. The manipulative era (1890-1990) is marked by the induction engine and electricity. This has an immense influence on the city and the water system. The car, industry, industrialized building processes and technology creates a new spatial order. This results in a situation whereby technically everything is considered possible - at the cost of neglecting the "natural" laws of the water system. The power that started with the steam engine accelerates in this phase.

The development of sewage and potable water infrastructure segregates urban water into three systems; groundwater level control, wastewater and drinking water. Most of this urban water system disappears underground while the car claims more and more space. Stagnant, malodorous and badly lit water bodies where unsightly, unsanitary and results in numerous deaths through drowning; the city thus filled in this water, reducing the ratio of open water in the city.

Even though the water structure of the polder city remains important for drainage, discharge and storage, it is no longer used as an element in the city's urban design. At this time hydraulic filling techniques and industrial building methods become prominent. Blijdorp, an expansion of Rotterdam, is the perfect illustration of the first urban type that comes with this new method of building-site preparation. The Housing Law (1901) makes it mandatory for municipalities larger than 20,000 inhabitants to develop expansions plans. This law gives a boost to the nascent urban design profession, which until then are designed by engineers and architects. Considering the way neighbourhoods are built it is very hard for the municipality and developers to follow plans. The first expansion plan for Rotterdam (1906), which includes Blijdorp, is more a combination of private developers' plans than an independent urban design.

Eleven years later, after much iteration of the urban plan and ongoing disputes with developers, the municipality decides to appropriate the land and administer the area themselves. The added advantage of this decision is the fact that they can prepare the whole site at once with the new technology of hydraulically filling. The largest advantage of this decision is that no consensus for the design is required prior to filling the site with sand because this provides the foundations for a flexible plan. In this case, the design and outcome is disconnected from the underlying polder pattern, the pattern of land, the water and cultural heritage. Building-site preparation, the technology of balancing land and water, also becomes disconnected from the urban design. However, due to the fact that the technology is not perfect at that time, one important spatial connector to the natural system is surface water. The surface water system is in Blijdorp still part of the construction and urban design (chapter 5a), but this will change after WW II.

Improvements in technology after the Second World War provide a second urban type of the Manipulative Phase (chapter 5b). During this period urban areas are dramatically expanded, leading to a much greater separation of urbanism and landscape. Water is overlooked as an urban element due to the use of sand filling – water turns into artificial gesture. This fits the technocratic paradigm of a man-made culture; known as the *maakbaarheid* principle.

Lotte Stam Beese, municipal urban designer in Rotterdam, responsible for expansions like Pendrecht, Lage Land and Ommoord writes about the influence of bad soil conditions and the effect that applying a layer of sand has on the urban design:

The failure starts with the choice of the location of the new residential area. We have no good choice for a proper place,... [...]. The result is that due to the need for houses the residential areas come about with a rational-theoretical model, just like the Roman army camps, and miss the natural geography that used to characterise former settlements: the valley, the river crossing or mouth, the presence of water or the safety of a mountain tip. The presence of the geographical characteristics and the internal coherence with them produced the urban design; it gave these settlements and their resident's identity. Therefore it is not surprising that the current city expansions show great resemblance with the Roman army camps in lack of morphology. These camps also had no structural connection to their geographical situation, are independent and characterised by a singular function. Ommoord is built on the worst soil conditions possible. To be able to build there the whole area has to be drained with sand piles. This is not only very expensive but also restrictive in the detailing of the urban plan. [..]All these simple impossibilities produce an urban plan without an inoffensive character and become emphatically wanted and technically efficient. (Stam Beese)

The third and last type comes about in the 1970's when partial sand layers are applied to keep some of the original landscape in the urban design (chapter 5c). In the 1970s the post-war era is considered a technocratic period with narrow minded views on social structures. There is a strong urge to free society from these conventions in search for a real identity of the city. In reaction to technocracy and a man-made culture, a respect for nature develops and is included in territorial management. Rachel Carson's seminal analysis of post war development in *Silent Spring* (1962) exposes how the significance man's impact on the environment is also felt in Dutch planning. In addition the report by the Club of Rome, *Limits to Growth* (1972), and the oil crisis in 1973, put economic growth and environmental impact in a clear perspective. In the 1970's, nature and ecology becomes more important in spatial planning and with this the landscape architect becomes a new player, reintroducing a connection to the landscape as a spatial element in the city (landscape urbanism). This leads to a new strategy involving less sand filling and keeping the original landscape as public space in which water is an important element.

Adaptive power
(Chapter 6)

After its introduction in the 1970's, environmentalism takes a further twenty years to enter mainstream policy and practice. With changing weather conditions, this process is in constant development and revaluation. The technical and engineering solutions developed in the post-war manipulative era are now considered inadequate against climate scenarios. The era of using pipes and pumps, with a civil engineering focus, are over. Water must be reintroduced into the urban design of the cities. This requires a spatial approach where fluctuations in water supply and ecological water systems are carefully considered.

In the Netherlands, during this time, the approach towards urban planning becomes liberal and de-centralized. National planning reports set out very general guidelines and have a greater focus on economics than spatial order. However, water is also integrated in the national planning reports like the 'Nota Belvedère' in 1999 and 'Anders omgaan met water, waterbeleid in de 21e eeuw in de stad' in 2000 (Another way with water, water policy of the 21st century). The former is about increasing attention towards history and landscape and the latter is the response to potential disasters from the 1990s and how to change attitudes towards water. Both emphasise a strong re-orientation towards nature and culture on the national agenda.

Examples of how water protection become the basis of the urban design can be seen in three recent developments in Rotterdam; Prinsenland, Nesselande and Zestienhoven. The strategy that is used in Prinsenland is called "Urbanized Landscape". Here the existing landscape and settlement are retained and used as part of the development. Carefully situated in between are new residences on partially filled sites. In Nesselande, water is introduced as the qualitative basis of the plan. The project has been developed using ecologically sensitive materials, district heating and subsidised solar energy. The water quality is managed through a self-cleaning open water system for drainage and a separate reservoir for storage.

In Zestienhoven water management strategies take another approach due to the area being low and wet with a high degree of seepage. Here the urban design strategy returns the site to the original open water gridded polder pattern; waterways are excavated from the layer of sand, further sand filling is laid to prevent seepage and the polluted soil capped while preserving the original landscape structure.

The ten percent surface water rule, demanded by the water board, is located to the south where there is a natural height difference. However, when detailing the waterway it turned out that the seepage there is so severe that the building of a waterway can only be done when the soil is heavily sealed. The problems manifest themselves usually after thorough calculations that are only done while implemented. On the historical map on the location of the high seepage little islands are visible. These islands make sure that the grounds do not break open and are therefore offer the natural solution for the problem. It is the logical spatial solution for the conditions belonging to the landscape characteristics of the area. This example confirms that hydrological conditions are constantly evolving, an element that sets the agenda for the land use. Also, that the factor time needs to be incorporated into the organization of urban development, technology needs to be orchestrated and balanced out with the natural conditions of the site.

The power of a tradition
(Chapter 7)

Having investigated the development of polder cities, the research shall finally gather principles and themes that have evolved over time which are considered useful for the future of Dutch urbanism.

Firstly, the most important features taken from each phase are compiled (refer to table 7.1). The initial conclusion is that an analysis of phasing based on the technological possibilities and attitudes towards the natural system has been very profitable. The table in itself offers enormous insight in the coherence of development per phase and also lines of development and their logic per feature. The features are grouped in three categories according to scale and level of abstraction: context, discipline and the spatial intervention.

After studying the features identified in the systematic analysis the evident conclusion is that urbanism has moved from a natural to a cultural system. This attitude change has been brought about by technology development;
1) allowing constant increases in scale (in water management and urbanization) while,
2) reducing perceived levels of vulnerability to water and
3) creating a division between the landscape and urbanization.

Over time the engineering discipline has developed in terms of organization, specialization, and professionalization – it is regarded as the first formal profession dedicated to making cities. On the other hand the urban designer as a relatively new player, develops during the twentieth century. Urban development has evolved from; working with “urban principles” to aesthetic design, from tactics to strategy, from small to large, from hydrology to hydraulics, from flexible to fixed, from nature to culture and from specific to interdisciplinary.

The most evident division between the two disciplines occurs at the moment urbanism turns from effectively creating polder cities to efficiently producing the contemporary aesthetic and functional city ideal. Sand, used in site preparation, is the most significant literal and metaphorical material associated with this disconnection. Sand, while a relatively inane material, allows construction to occur almost anywhere throughout the lowlands, using standard building techniques and providing banal and standardised outcomes. This creates a wedge between the aesthetic and socio-economic functions associated with urban design and the technical resolution of the site domain associated with civil engineering.

The features involving spatial interventions include: coherence of the urban structure, relation to the territory, the water function, the relation between urbanism and water, building-site preparation and the urban model. Of these, interventions that have greatest impact on natural systems include:

- the water and urban structure,
- urban patterns,
- groundwater and surface level and
- urban surface.

These require an interdisciplinary approach between the civil engineer and the urban designer.

The principles that involve an interdisciplinary approach include;

- the boezem principle (digging, canal filling building-site and mill),
- the polder principle (digging singel, lowering groundwater level with steam engine),
- the *maakbaarheid* principle (hydraulic filling, drainage system and induction or electrical pumping station) and
- the partial principle (filling, building and street locations, keeping landscape structure for green).

The logic that comes out of the different phases of the systematic analysis is more precisely defined by the use of features or fundamental characteristics that show the continuity and evolution of the Fine Dutch Tradition. This red threat is at the base of the urban archetypes that are produced by this logic, these include:

- *The adaptive city*: well balanced with the natural system and highly flexible based on external conditions.
- *The urban archetype of fertility*: profiting from hydrological logic, cooperation and boldness.
- *The urban archetype of systemization*: increased concentration, increased movements, increased power, and increased wealth; however low levels of hygiene, less social equity and less nature in the city.
- *The urban archetype of maakbaarheid*: ability to disregard the original water system due to technology.
- *The urban archetype of adaptive manipulation*: “work in progress of the safe, sustainable, healthy but vulnerable city”:

Finally, the definition of the Urban Fine Dutch Tradition for the urban context is: *The Urban Fine Dutch Tradition is a dynamic tradition of making* *urban plans using the parameters of the natural system – linking in an efficient way the hydrological cycle, the soil and subsurface conditions, technology and urban development opportunities.*

However, after the Industrial Revolution the perspective shifted to the cultural system, developed significantly during the post-war era (1945-1970). Since the 1970s this sentiment has changed, attracting a return to previous development approaches. The accelerating man-power during the post-war period could be considered as a break in the tradition or even the absence of a Fine Dutch Tradition. However, it is important to acknowledge that the capacity of *maakbaarheid* could only develop as a consequence of the Urban Fine Dutch Tradition, because of the accumulated experience and a large body of knowledge of natural systems. The designs of the city as a three dimensional object have no connection with how it is constructed: any urban plan as aesthetical design is possible with the available means. When any aesthetical urban design is made technologically possible on any type of soil conditions not only the relation to the natural system is lost, but also the relation to the technology itself: the way the city is actually build, is constructed, plays no part in the urban design.

The future sustainable and climate proof water city can be developed based on the relationships between engineering and urban design. The interdisciplinary principles of the Urban Fine Dutch Tradition could again bring disparate urban disciplines closer by using natural system as a starting point. Thus collectively spatial qualities can be considered, technology determined and “spatial technology” resolved. An interdisciplinary approach leads to combining language, methods, concepts and integrating scales. Concepts like ecosystem services can play a role, a more generalist approach and the integration of knowledge at a stage where it is most effective for sustainable development.

Curriculum vitae

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Born May 31st 1971 in Capelle aan den IJssel, Netherlands
Bachelor in Architectural Design and Master in Art and Culture Science
Married to Daan Schipper, mothering three children

Education

2002-2011	**PhD Urbanism The making of a tradition: polder cities,** Technical University Delft.
1993-1996	**MA Art & Culture Science**, Erasmus University Rotterdam. Specialization history and theory of twentieth century architecture, urban design and landscape architecture in the western world.
1995	**Graduate School of Architecture, Planning and Preservation**, Columbia University New York (U.S.A.). Studies in tectonic culture (K. Frampton), The body of architecture (A. Benjamin), Structuralism-poststructuralism-modernism (R. Krauss), The planning of New York city (R. Schaeffer), Patterns of metropolitan development (R.D. Yaro), Planning history and the physical structures of cities (E. Sclar).
1988-1993	**BA Architectural design**, Art School Rotterdam. Architectural design, styling, exhibition design, art and culture history.

Experience

2009-2011	**Environmental Design, researcher at the TUD** Education in the Master Urbanism, Master Landscape, European Master in Urbanism. Research project Energy-atlas and Friese 11 Cities. Member SKB stakeholder table.
2009-2011	**Innovation & Environment, researcher at TNO** Projects: Urban design with soil: connection the domain of the underground with the domain of the spatial design, Urban Climate Framework: system approach that described the urban system and makes connections between threats and measures in different domains, ROESS: Ecosystem services in the urban domain, Geothermical manifestation: connection between geothermical sources and urban energy and warmth demand, Urban Gesus: development of a sustainable approach toward area development. GEN, area development CO2 neutral.

2002-2011 **The Fine Dutch Tradition: polder cities**
PhD-research at the University of Technology Delft, faculty of Architecture, department of Urbanism. De research aims at the relation between water management and urban design. In order to tackle current and future problems with water a greater understanding of the 'fine tradition' will offer an important layer of knowledge. This research must give a representative idea of historical, current and future relationships between urbanization and water management in the polder cities.
Projects/publications:
2008 Urban water in Japan (editor)
2007 More Urban Water, Design and management of Dutch water cities (editor)
2005 Atlas of Dutch water cities (editor)
2004 Exhibition International Architecture Biennale Venice, Italy (editor)

2007-2011 **Free Lance researcher/lecturer**
Architecture historical analyses: De Doelen Rotterdam, American Embassy, The Hague, Netherlands Congress Centre Den Haag, WTC Rotterdam, Hotel Savoy Katwijk aan Zee, Amman building Rotterdam, Fodor building, Hotel Centraal, urban structure Delftsestraat in Rotterdam, Sportlaan-Zorgvliet and Waldeck in Den Haag.
Lecturer: Academy of Architecture Tilburg, Art School Rotterdam, Art School Arnhem.
Exhibitions: Netherlands Architecture Institute, International Architecture Biënnale Rotterdam, Boompjes 2001, 'Post-Rotterdam' for Porto 2001.

2000- 2011 **Job Dura Prize**
The Job Dura prize is a two year prize within architecture, urban design & society in the region of Rotterdam. Every prize has a different theme: 2000 public space, 2002 youth, 2004 water, 2006 safety, 2008 re-use of buildings, 2010 educational building and 2012 cultural buildings. Research into the theme and coordination of the jury.

2003-2009 **Maakbaar Landschap (Man made Landscape)**
Initiator and project leader (with Marinke Steenhuis) for an extensive research into the practice of the Dutch landscape architects in the period 1950-1970. First Phase was interviewing 18 retired landscape architects on video to be source material in archives. Second Phase was writing an article for the Blauwe Kamer and organizing as debate. Third Phase of the project landscape architects 1945-1970. Coordination of content and finance of research done by five researchers looking into the change of the Dutch landscape in the period 1945-1970. publication (NAi Publishers, 2009)

1999-2001 **Waterproject 1854-2001**
Initiator and project leader (with Mariëtte Kamphuis) of the festival *Waterproject 1854* part of Rotterdam Cultural Capital of Europe 2001. The festival contained a publication: The

Water Project, a nineteenth century walk through Rotterdam; two exhibitions: the drawing cabinet (original drawings of the project) and an out door exhibition about studies (Rein Geurtsen & Partners, Juurlink & Geluk, S333); design studios with designers of the municipality and a closing debate.

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Acknowledgements

I have never felt like a lonely cowboy on the prairie but always in the comfort of a polder model. This has not been a lonely project, on the contrary this project is the result of the enjoyment of people who joined me and made it fun and interesting to persist. Besides an inspiring and energetic context, you really need to be persistent to remain behind your computer and stay on it. There was a time when I did not feel positive energy from this project, but I never walked away. Here I finally have the opportunity to thank those who helped me to stay on it!

Firstly I'd like to thank the people who have not done this project before me, it was way over due. Secondly, I'd like to acknowledge the people who actually built and developed the polders and polder cities. The theme of climate change, and the sensitivity of changing environmental conditions within these territories, offered the prime incentive to work. The anticipation of the changing climate is the foundation for this research - so I have to be grateful to this despite our need to fight it.

Following people in history and climate the two most important drivers of this project are; my promoter Han Meyer and co-promoter Frans van de Ven. Han literally let me do it my own way importantly giving me confidence and freedom. It was the fertile ground for not only this project but also some others that we also worked on together with great result. Frans van de Ven is the important link to the world of engineering, which could not be excluded in this research which focused largely on the relations between engineering and urbanism. Frans' listening and explaining skills offered crucial support.

MaartenJan Hoekstra and Maurice Harteveld have been my mates all through the process; laughing, arguing, gossiping, traveling, drinking and eating. As "paranimphs" they are my witnesses in my marriage to science. We shared the Urban Lounge that not only burned down but collapsed in the end, and I miss it up to this day.

I'd like to also acknowledge other colleagues at the Department of Urbanism whom in many ways have made my working life a joy. First those from the chairs Urban Compositions and Environmental Design at TU Delft, and especially Daan, Luisa, Linda, Henco, Ana, Joost, Roberto, Camilla, Taeke, Machiel, Sybrand, Dirk, Per and Meta. From other departments Wout van der Toorn Vrijthoff of real Estate and Housing for making the publication More Urban Water with me and of Civil Engineering Rutger de Graaf. Rutger showed me the fascinations of the civil engineers, showed me around in Japan to the best Tempura Kings, to the best Indian presentations and especially how to the have the best time there! I have it all on film and on paper because after all this entertainment we make the publication Japan Urban Water.

My new colleagues at TNO for the past two years have been helping me in the analysis phase of this research and they probably do not even know it. The cooperation in a group with policy developers, engineers, planners and urbanists has been very fertile for thinking. Projects about knowledge brokerage and boundary spanning between domains with particular concepts and languages has been very helpful.

For the research itself I naturally dependent on the people in the Municipal Archive in Rotterdam, Els Schroder and Martijn Verbon, and of Public works, Theo de Bruin. They did their best to help me find the treasures. For the newer projects I interviewed the urban designers Joost Schrijnen, Frits Palmboom and Matthijs van t Hoff and civil engineer Peter Spakman Then there are many others reviewing my papers or listening to my presentations and giving me the feedback I needed to make this interdisciplinary project worth it.

I build on my friends, they are the dikes, ditches and pumps of my polder model. One group that also contributes to my life as a researcher and accompanied me in projects like Waterproject and Maakbaar Landschap are the Intimic: Mariette Kamphuis, Marinke Steenhuis, Wijnand Galema and Dorine van Hoogstraten. We shared and discussed the architectural, urban and landscape history in contemporary times that shaped my research skills in a large way. Mariette was first my mentor, then partner in crime and foremost a good friend to share a day at the library, typing away.
Also in making this last product my friends have been there to make it easier. Maarten Laupman indulged my directions for making the beautiful photo of the cover, Minke Themans for doing the graphic design of the cover and advising for the interior and Stella Smienk making the info graphics.

In this polder model my family is not to be missed. My mother for giving me the enthusiasm, creativity and trust to do what I like. My father for the discipline, curiosity, for the “gezelligheid” and support in going through 130 years De Ingenieur. With a list of selected terms Ad spend many days sitting next to me, taking each 65 years. Luckily something was in it for him because he ended up copying his Professors articles when he was a student at the TU Delft. He would take articles about batteries with him on a holiday spending days in understanding what they were really about. Now that’s staying on tops of things!

Most important condition in life is of course my family Daan, Juri, Otis en Grietje-Nel. Many times when I took up too much time I would point out this moment that in the end I would thank him making room for me and this project. It would not have been possible without Daan. The children are my joy and everything and of course most important in my polder model. Juri, my oldest son has been asking what I was doing behind the computer every weekend and most holidays. I explained to him that I was writing a book, a “Proefschrift”. Somehow his whole experience of a mother being either pregnant or behind the computer and most of the time both, did not bother him. On the contrary it seemed very good to him because he would say: I

also want a “Proefschrift”. Now the project is finished and I will take some time to see if it was worth it, although the reactions I already get make it well-worth it. The day Juri will ask my advice about an eventual academic carrier, I can advise him from understood experience. I know for sure that fulfilment for me, and I hope also for him, is in “the making”. If for him that means making bikes or whatever makes him happy, I will be happy too.

Propositions

1) The Urban Fine Dutch Tradition is a dynamic tradition of making urban plans using the parameters of the natural system – linking in an efficient way the hydrological cycle, the soil and subsurface conditions, technology and urban development opportunities.

2) Industrial Revolution has brought an uncomfortable spit between engineering and urban design. The Fine Dutch Tradition is the foundation for successful joint ventures in the future.

3) The Fine Dutch Tradition is important to Dutch urbanism today and tomorrow, because it is the foundation for sustainable, attractive, waterproof and climate-resilient cities.

4) Sustainability is the capacity of making a sensible choice for enabling technology taking the perspective from the natural system, to design the human system. Both urban design and building-site preparation are trait-d'unions between the natural and the human system.

5) Efficiency is a dynamic concept which beholds the fact that the aimed at perfect end condition will never be reached.

6) Weak and wet soil and subsurface are too instable for privatization and decentralization: a polder city needs a polder model.

7) The hammer is broke, long live the hammer.

8) Getting a PhD is proof of the capability of standing strong in a slow decision making process, where all parties have to be heard: a true polder model.

9) The nature of the Dutch discipline of urbanism is based on the wet and soft soil conditions.

10) Form follows sustainability.

Stellingen

1) De stedelijke Fine Dutch Tradition is een dynamische traditie in het maken van stedelijke plannen vanuit het perspectief van het natuurlijke systeem om, op een efficiënte wijze, een grote coherentie tussen het natuurlijke systeem – de hydrologie en grondcondities – en stedelijke ontwikkeling te verkrijgen.

2) De Industriële Revolutie heeft een onwenselijke scheiding aangebracht tussen de disciplines civiele techniek en stedenbouw. De Fine Dutch Tradition vormt het fundament voor een succesvolle samenwerking in de toekomst.

3) De Fine Dutch Tradition is belangrijk voor de hedendaagse en toekomstige stedenbouw omdat het aan de basis staat van duurzame, aantrekkelijke, water- en klimaatbestendige steden.

4) Duurzaamheid is een handelingsperspectief waarbij de keuze voor de toepassing van techniek wordt gedaan vanuit het natuurlijke systeem en in samenhang met het stedenbouwkundig ontwerp. Stedenbouw en bouwrijp maken zijn trait-d'unions tussen het natuurlijke en het humane systeem.

5) Efficiëntie is een dynamisch concept waarvan de onmogelijkheid om perfectie te bereiken een karakteristiek is.

6) Een natte en slappe bodem is te instabiel voor privatisering en decentralisering: een polder stad heeft een polder model nodig.

7) De hamer is stuk, lang leve de hamer.

8) Het behalen van de doctorsgraad is bewijs voor doorzettingsvermogen in een langzaam besluitvormingsproces, waarbij alle partijen gehoord moeten worden: het polder model.

9) De natuur van de Nederlandse stedenbouwkundige discipline is gevormd door de natte en slappe grondcondities.

10) Vorm volgt duurzaamheid.