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Water inSight

An exploration into landscape architectonic transformations of polder water

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Table of contents

Introduction

Water inSight is a reference work that visualises the Dutch 'water machine' in the polder landscape from a landscape-architectonic point of view, with the aid of technical and spatial-analytical drawings, images, plans and experiments.

Chapter 1 explains the way in which this book offers a new and relevant contribution to the countless existing publications on the Dutch lowlands and water design. As a starting point and source of inspiration for landscape-architectonic interpretations and adaptations of the lowland polder-*boezem* system, we introduce a range of visual water elements from the classical gardens of Villa d'Este, Vaux le Vicomte and Chatsworth House.

Chapter 2 provides an overview of the Netherlands and its water, with a special focus on the polder landscape. Without this complex, man-made water system that continuously pumps excess water from the low-lying polders, the landscape would soon be transformed into a swamp. The maps included in this chapter make it clear that polder water takes a great variety of forms and adaptations. A huge number of individual waterworks are needed to ensure the water goes where we want it to go. Owing to the effects of climate change, adapting and renewing the water system is now a necessity.

Chapter 3 explicitly describes the difference between a peat polder and a lake-bed polder. The inventiveness and untiring efforts of our forefathers has made it possible for us to live in an area that is largely below sea level. The polder landscape and water design are inextricably linked to each other. There are over 3500 [1] polders in the Netherlands, each of which represents a distinct spatial entity in terms of water technology, although some are more visible as such than others.

Chapter 4 provides a detailed description of the water forms and patterns of six polders - three peat polders and three lake-bed polders. Both categories are representative of a larger group of similar polders. Analytical drawings are used to illustrate the location, elevation and workings of each of the water systems, thus revealing a wide range of lowland water elements, both visible in the landscape and hidden under the surface.

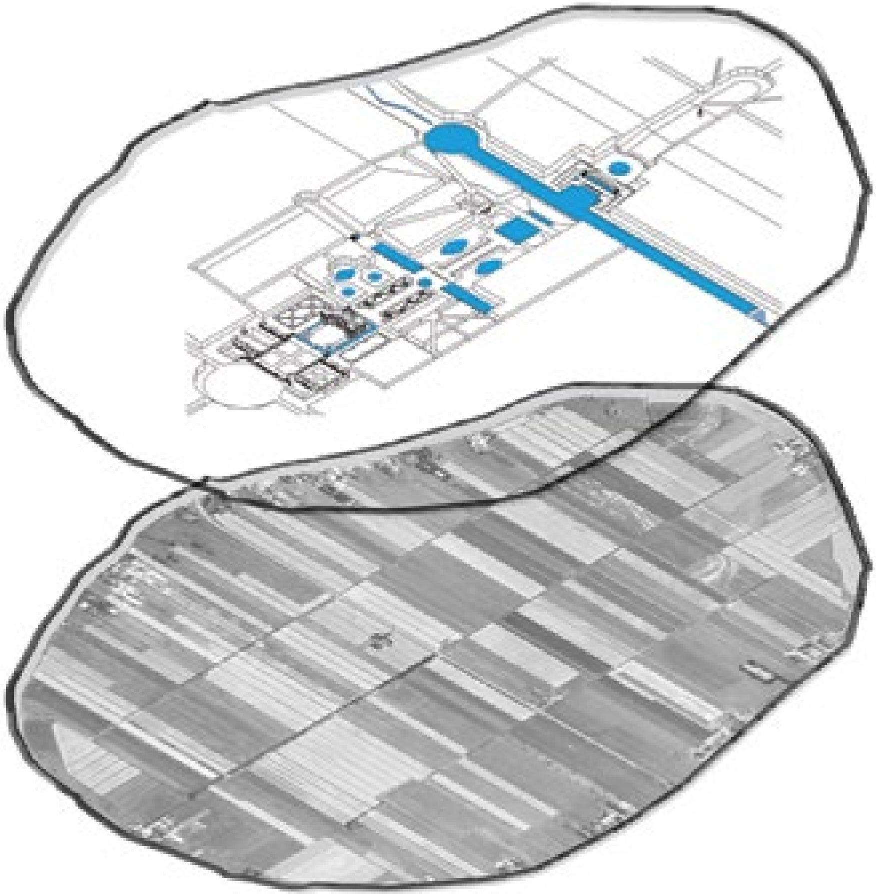
Chapter 5 presents four projects in the polder landscape that are either in development or recently completed, and analyses them in the same way as the polders. The designs are described with reference to the typology derived from the classical garden. The projects – the Eendragtspolder, the Belvedère museum, Wickelhof Park and the Onnerpolder pumping station – were chosen for their landscape-architectonic qualities and because they vary in scale.

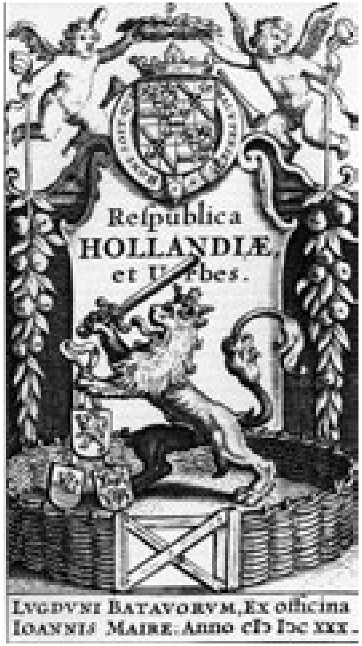
Chapter 6, finally, uses three design experiments to illustrate the direction of future landscape-architectonic water design in a peat polder and a lake-bed polder.

1 Steenbergen, C., Reh, W., et al. (2009). *The Polder Atlas of the Netherlands*. THOTH, Bussum

The water garden as a source of inspiration

Montage of Vaux le Vicomte in the Zoetermeerse Meerpolder





The Netherlands as a garden

The Dutch lowlands are an artificial landscape, which was described as an enclosed garden by Hugo de Groot as early as 1630, on the title page of *Respublica Hollandiae et Urbes*.[1]; It is a garden that has been wrested from the sea and brought to bloom, and is at constant risk from flooding.[2]

This unique polder landscape was created through a combination of technology, art, science and imagination. Creative labour was needed to make the new land, obtained through reclamation, diking and draining, into a habitable, unique and beautiful man-made landscape; a land of a thousand polders, each with its own water system, requiring continuous maintenance.[3]

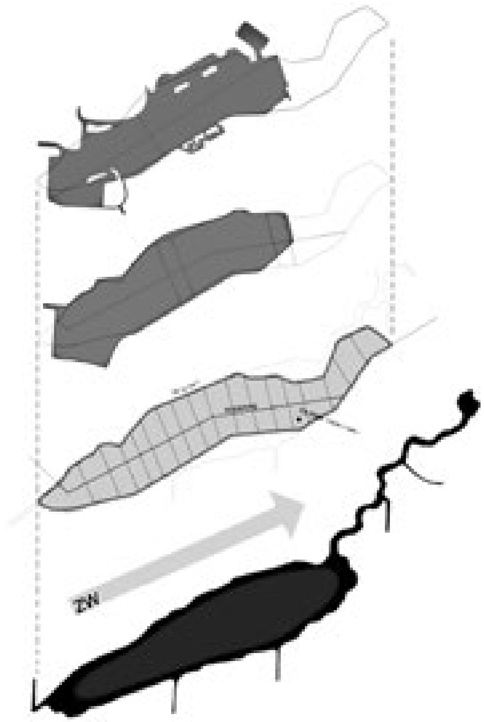
The need to gain control of the water laid the foundation for the structure of the landscape. The development of hydraulic engineering went hand in hand with the spatial developments in the polder-*boezem* system. Many constructed waterworks, of which the pump with its driving gear is the most notable, were gradually introduced into the polder landscape. The drainage pattern of the man-made landscape, together with the waterworks and land use, resulted in a spatial adaptation of the underlying landscape. The interaction between the lines of water, which come together to form patterns, and the corresponding waterworks, is unique to each polder and embodies its specific character, or 'genius loci'. At the same time, however, every polder-*boezem* system requires constant modifications for it to be maintained.

Apart from researching the working of the water system and the position of the waterworks in the system, it is interesting to examine the form of the water elements themselves. A ditch in a peat polder, for example, looks very different to a ditch in a reclaimed lake.

1 Bezemer Sellers, V. (2001). *Courtly Gardens in Holland 1600-1650*, Architectura & Natura Press

2 Schama, S. (1987). *The Embarrassment of Riches: An Interpretation of Dutch Culture in the Golden Age*

3 Geuze, A., Feddes, F. (2005), *Polders! Gedicht Nederland.* NAi uitgevers



Landscape architectonic landscape
Cultural landscape
Natural landscape

Knowledge of the technical workings of the drainage system in particular, of the composition of the system and the form of each water element in the polder will be discussed in detail in the following chapters. This knowledge forms the basis for a potential landscape-architectonic interpretation and adaptation of the polder water. The landscape-architectonic layer constitutes an adaptation of the man-made landscape, which in turn constitutes an adaptation of the natural landscape and lends meaning to the locus via the layer of landscape architecture. In the landscape-architectonic design, the sensory, symbolic and poetic aspects of the material 'water' are developed on a human scale.

In the classical villa, where the origins of the discipline of landscape architecture lie, water is incorporated in designs in many different ways. In the foreword to the book *Architectuur en Landschap* [4], Sébastien Marot refers to the garden as 'a representation of the landscape in situ' [5], the landscape being incorporated into the garden by means of a landscape-architectonic adaptation. Water designs for a villa can therefore be regarded as a source of inspiration for the adaptation of polder water.

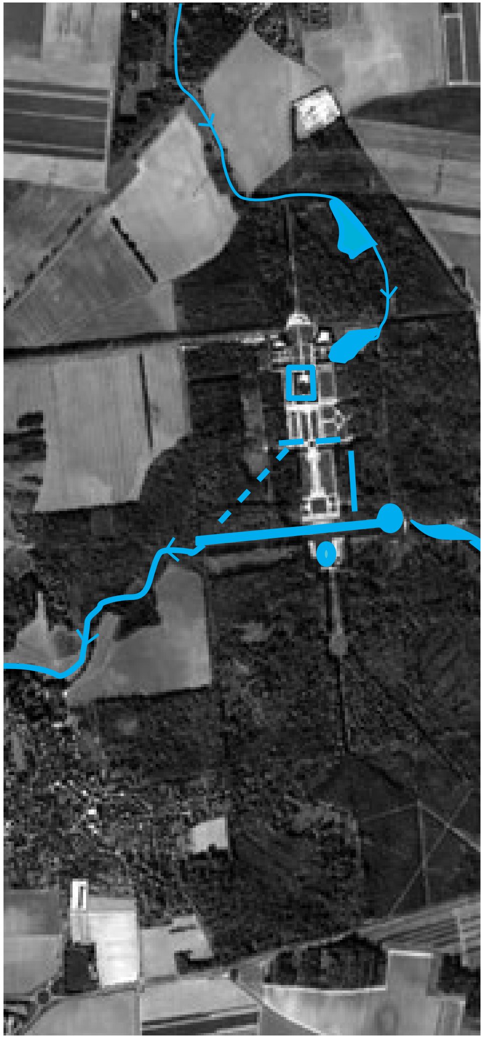
Given the differences in scale and topography between the gardens discussed and the flat polder landscape, it is sometimes difficult to compare them. Nevertheless, the study can serve as a first step in a landscape-architectonic interpretation of the existing water elements and their composition in a polder. Moreover, the landscape-architectonic perspective can provide inspiration for necessary changes to the polder-*boezem* system in the future.

An analysis of villa gardens involves looking at the effects that the architecture has on the water landscape and, perhaps even more importantly, the effects that the water landscape has on the architecture. This relationship also exists – in a latent form or otherwise - between the architecture and water system of polders in the Dutch lowlands.

4 Steenbergen, C., et al. (2003) *Architectuur en Landschap*. THOTH

5 'In situ' is een Latijnse uitdrukking die 'in plaats' betekent.

N 0,5 km



N 0,5 km

N 0,5 km

Water design in the garden of Villa d'Este (IT), Vaux le Vicomte (F) en Chatsworth House (GB) connected to the natural streams of its location

◀ Water layer on aerial photo Villa d'Este

Water layer on aerial photo Vaux le Vicomte

Water layer on aerial photo Chatsworth House

The water garden

Water, present in the form of a flow or spring, can be incorporated in the garden in various ways through landscape-architectonic means. For example, where water flows or rises to the surface, it can be 'captured' in the form of an architectonic object. Such architectonic objects, which not only have a possible symbolic meaning but can also form spatial links between the various levels of scale of a building and/or garden and/or site and landscape, are known as active composition elements.[6]

Examples of active composition elements in the relationship between building and landscape are the loggia, stoa, patio, arcade, balcony and belvedere. Active composition elements such as these are used to imbue the space with a special meaning and experience.

Water usually plays an important role in a landscape-architectonic design. Water design also has its specific active composition elements such as the spring, cascade, fountain, canal and grotto. Three gardens have been selected to give an initial overview of possible landscape-architectonic adaptations using water.[7] The selected gardens, in whose design water is an important visual and structuring feature, are of different styles, locations and periods. In all three designs – Villa d'Este, created in the 16th century near Rome in Italy; Vaux le Vicomte, created in the 17th century to the south of Paris in France, and the gardens of Chatsworth House, created in the 18th century in the Derbyshire Peak District in England – the position in the landscape is accentuated and articulated by means of the water design.

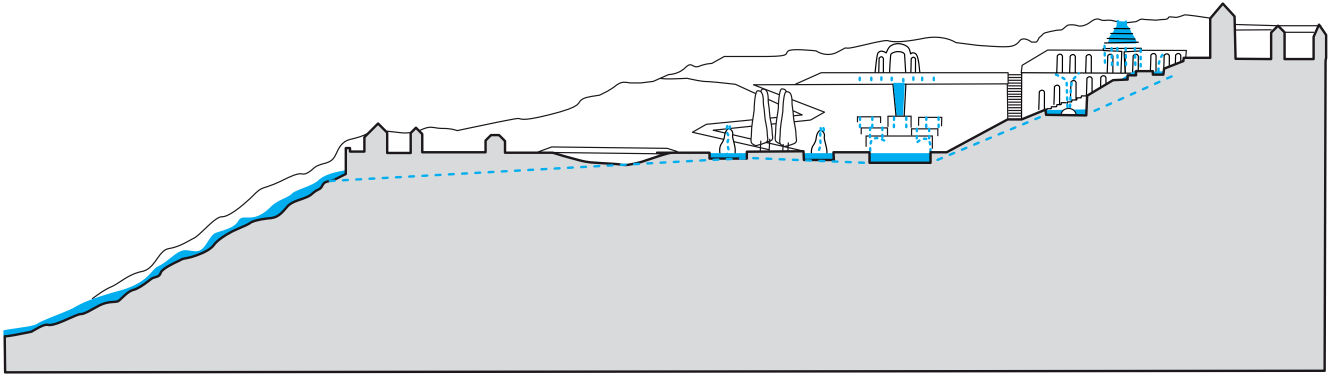
In the Italian Renaissance villa, the adaptation of nature by architects has long been influenced by paradigms from classical mythology. The transformation and architectural adaptation of the natural landscape, together with strong images from mythology, elevated enjoyment of nature (otium) to the desired intellectual and cultural level. Images of nature in the Italianate villa include the following categories: mountains, caves, waterfalls, rocks, ravines, rivers, lakes, woodlands, plains and sea.[7] At Villa d'Este, the architectonic dramatisation of these natural features can be primarily found in the water design. Some of the composition elements incorporating water have multiple meanings. A cascade, for example, is not only a formalised waterfall but also a hydraulic organ.

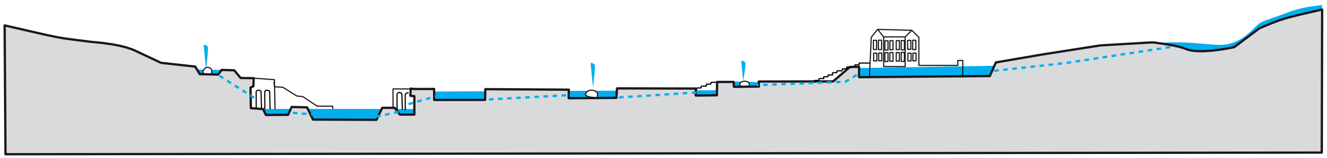
In formal French gardens, nature is architecturally controlled, laid out and designed in a representative fashion. Water is an important feature in these gardens, for example in the form of a Grand Canal (water axis), fountains and a water parterre. In the gardens of Vaux-le-Vicomte, the large reflecting bodies of water reinforce the contrast between flatness and relief.

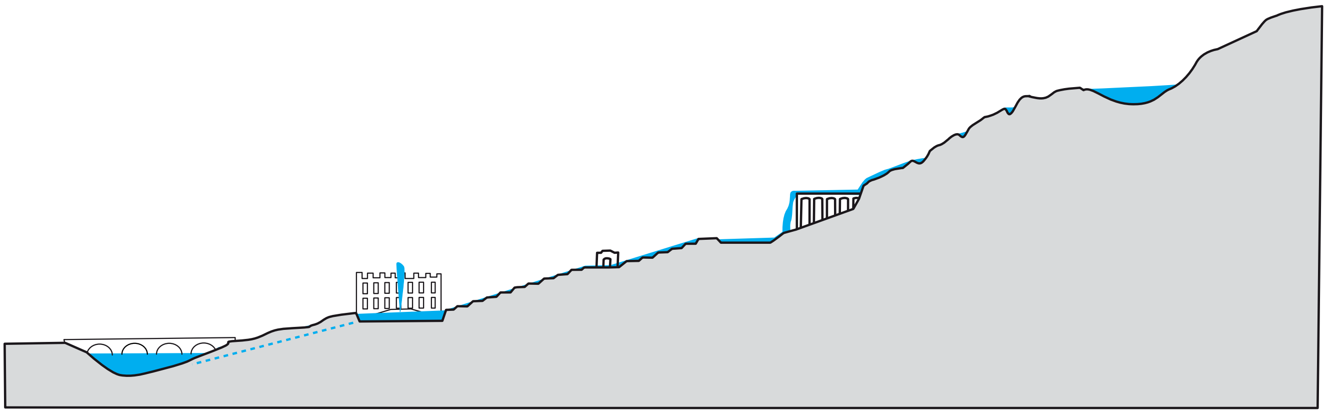
In English landscape gardens, the physical appearance of the natural landscape, with its complex, mainly flowing, forms is set against the architecture. The design is based on motion and flow. The composed elements of the garden are discovered one by one as the visitor walks through the garden. Water is an important visual

6 Zwart, J. v.d. (2005). *Tussen Haard en Horizon*. SUN

7 Vroom, M.J. (2010). *Lexicon van tuin- en land-schapsarchitectuur.* Uitgeverij Blauwdruk







Position of water gardens. From north to south: Chatsworth House (GB), Vaux le Viconte (FR) and Villa d'Este (IT)

◄
Section Villa d'Este
Section Vaux le Vicomte
Section Chats-worth House

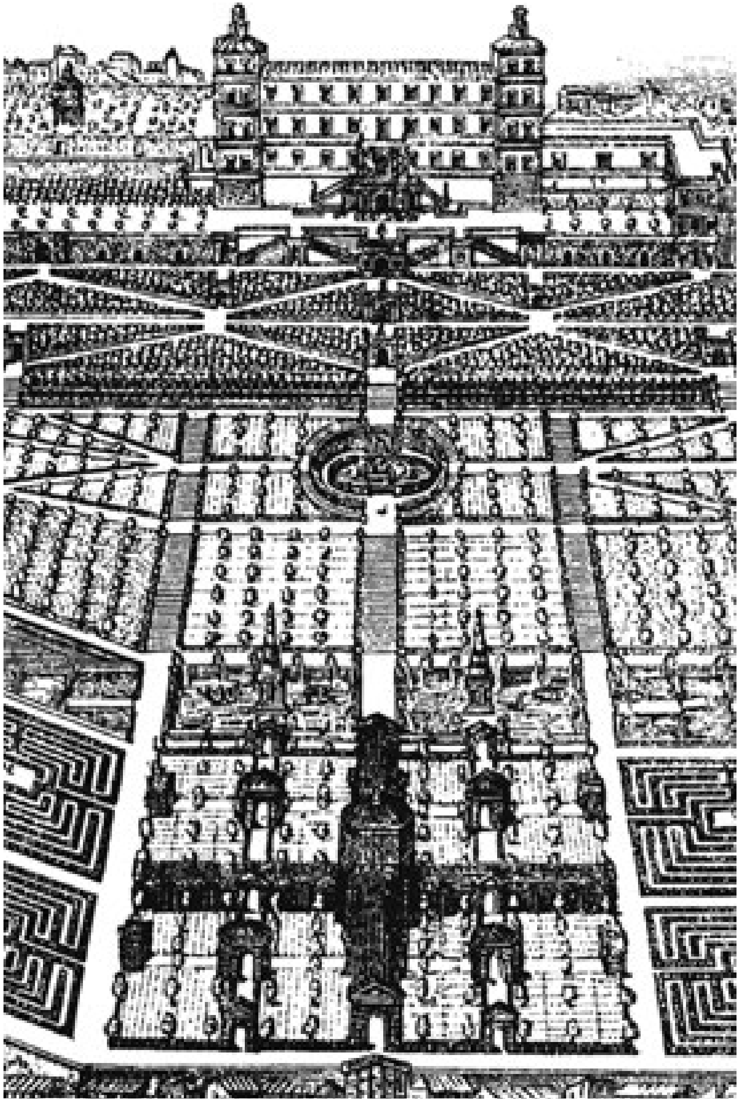
element, for example in the form of a hidden spring, in the 'mise en scene' of an endlessly flowing river or stream, or a bridge over water.

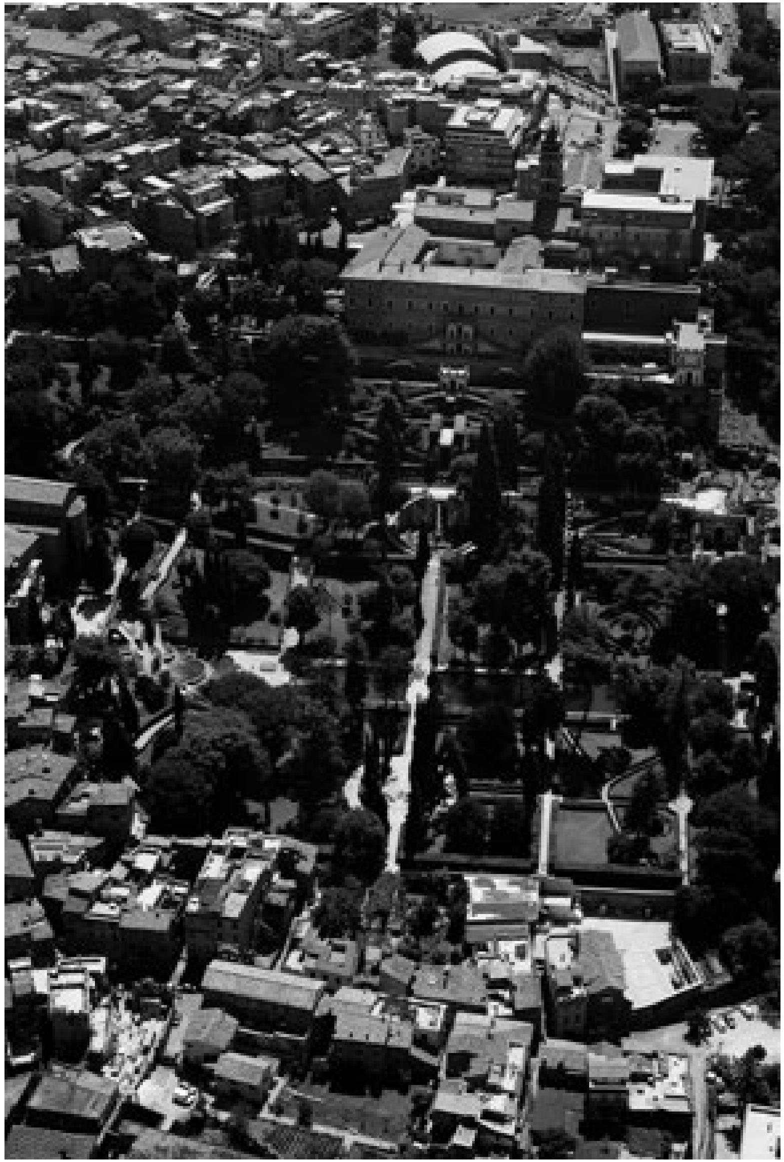
Topogaphy

There are considerable differences in elevation in the topography of the sites, particularly in the case of Villa d'Este and Chatsworth House. The situation of Vaux le Vicomte is most similar to the flatness of the Dutch polder landscape and, moreover, the visual language of the formal design of this French garden most closely resembles the rational integration of the water system in the polder, based on principles of land cultivation.

The practical way in which the water systems in the gardens join up with the existing streams and/or river systems is clearly visible in the aerial photograph. The water from the stream is channelled into the garden from the site's highest point, and flows out of the garden at the lowest point. As soon as the water leaves the site, it reverts to its natural course. At Vaux, the differences in elevation are less marked within the domain, but despite this the water does still flow into the garden from two sides – from the higher levels in the south and north – and flows out again via the valley.

In order to give the water greater strength or continuity, also in dry seasons, reservoirs are included on the edge of the site in each of the three gardens. Water collects in the reservoirs and is released as necessary. Due to this, and the fact that the water is transported through underground pipes, extra water pressure is created to send the fountains' jets of water high into the air. The water flow can be controlled and adjusted at all times. The connecting water courses between water features in a garden are not usually visible, thus giving the impression that the water rises to the surface without a great deal of effort being involved.

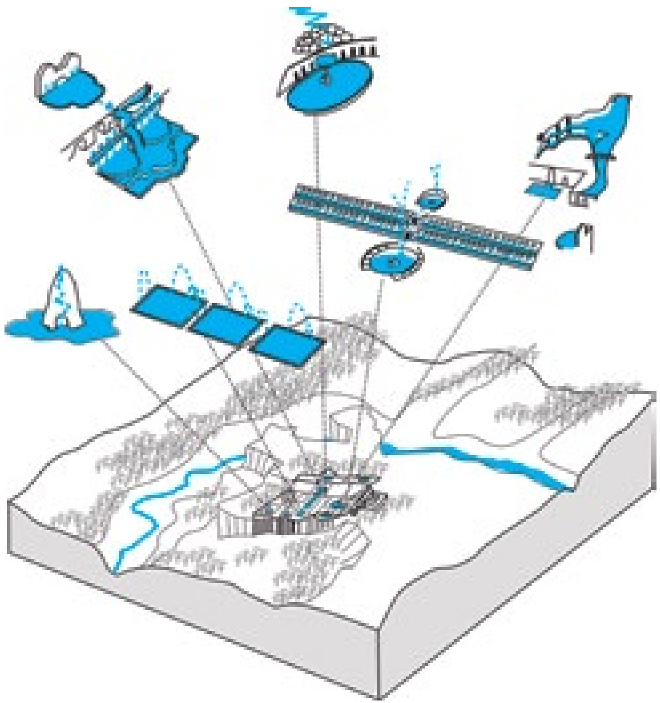




Villa d'Este: engraving and aerial photo

Villa d'Este

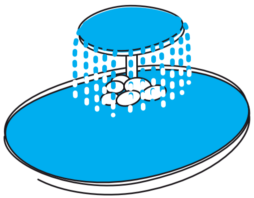
Water from the River Aniene flows through the city and into the gardens on the eastern side through an underground aqueduct. Part of the flow is then diverted into a pipe that carries it past the house (on the site of a former monastery). The water flows, jets or cascades down the slope via a range of different composition elements. The sound of water can be heard everywhere, and has a cooling effect during the summer months.



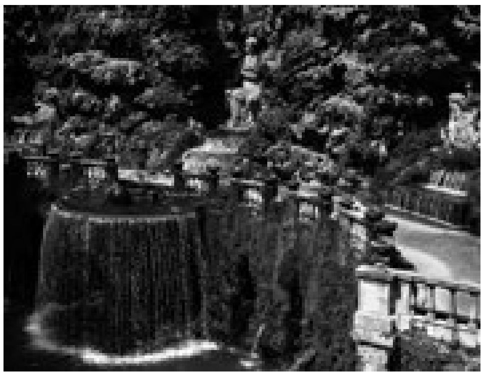
The fish ponds mark the end of the water's descent: from the waterfall and water curtain, via the grotto, to the fountains and down the slope, into the still waters of the ponds.

The aim was not only to visualise a mythological story, but also to demonstrate the technical skills on display in the garden's hydraulic works. The hydraulic skills were mainly visible in the large number of cascades and fountains on the edge of the garden. The garden is perhaps best known for its 100 fountains, a long retaining wall parallel to the villa at the top of the slope, from which water flows. This composition element could just as easily be called the '100 water spouts': the water in the bottom two rows does not shoot upwards, but falls in a downward direction. In the following section a number of active composition elements are described in greater detail.

Water curtain in the oval fountain
movement: falling
form: overflowing water surface

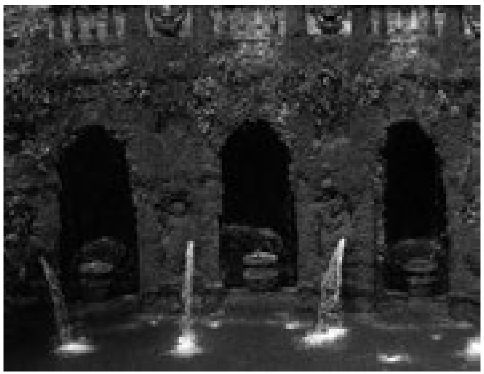


The water flows over the edge of the fountain's oval basin, then falls freely to a level several metres below. The edges of the basin and the constant inflow of water create a curtain of water that conceals and lends an air of mystery to the grotto behind it.

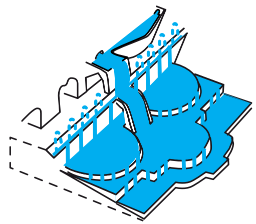


Grotto
movement: still
form: camouflage, underground water element

The oval fountain is fed by an aqueduct from the river and is the point from which the water is distributed to all parts of the garden. The water is forced upward through the many small holes, then descends to a lower level, in front of the semicircular nymphaeum and grotto. The grotto is in a dark, deep and damp position.

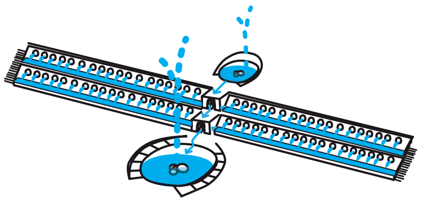


Water organ and cascade
movement: falling and flowing
form: open, channelled and stepped water surface.



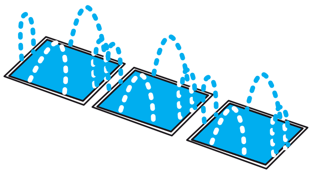
The force of the falling water pushes the air that operates the keys, which produce the trumpet music. From here, the water flows into the fish ponds, where it comes to rest. In the cascade itself, the water flows downwards over the stepped surface. The difference in elevation is formalised by the steps.

Water jet/spout
movement: spouting and falling
form: repeating, enveloping water elements



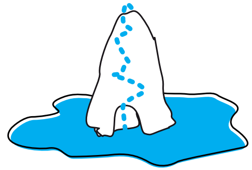
The 100 water jets at Villa d'Este are spectacular; they are arranged in two rows parallel to the slope, and the water spurts out simultaneously through lions' heads, in a downward direction. The stone is covered in moss, which lends a romantic patina, not only to the water jets but to all the other waterworks in the garden as well.

Water parterre with fountain
movement: still
form: reflective, enclosed/framed water surface

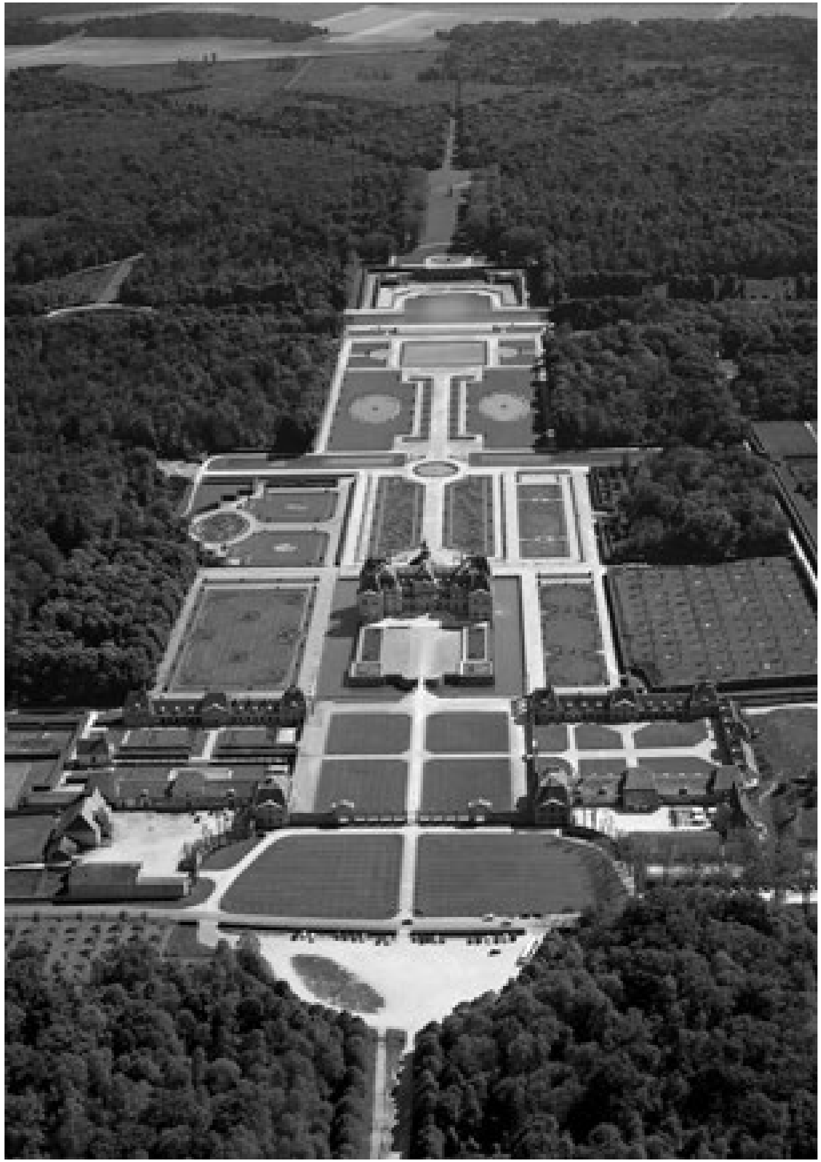


The large water basins, the fishponds, are situated on the garden's third terrace. Seen from above, the mirror surfaces form a point of stillness in the garden. Their position marks the most horizontal surface in relation to the steep part of the garden. A low wall encloses the basins.

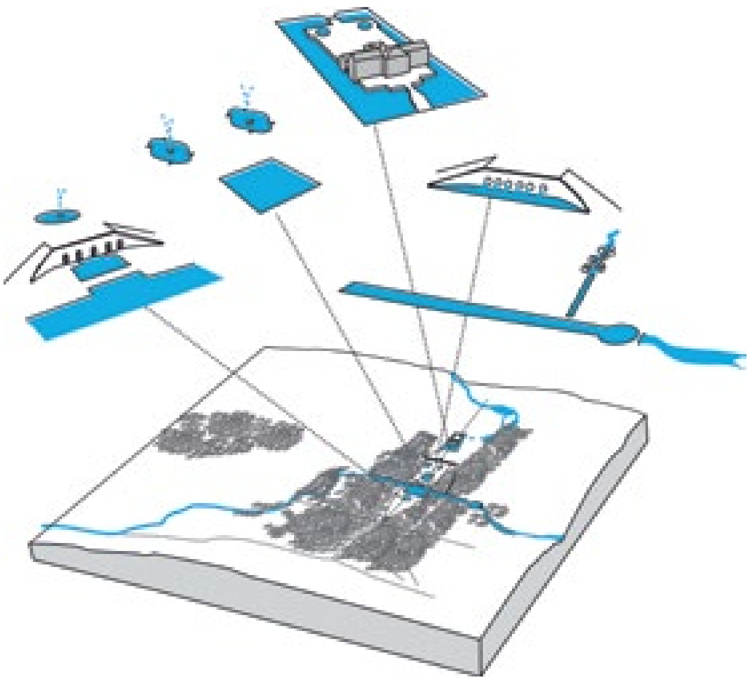
Fountain
movement: falling and overflowing
form: rocky water element



When water gurgles up or spurts out of the ground, it forms a spring or a fountain, respectively. In the lowest part of the garden, there are rocks moistened by rippling water and overgrown with moss. Since the water pressure is not very high, this feature can be categorised as a spring.



◂ Vaux le Vicomte: engraving and aerial photo



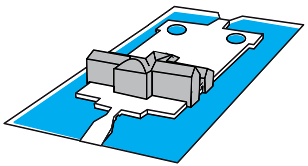
Vaux-le-Vicomte

The château Vaux-le-Vicomte and its formal gardens were constructed in the valley of a stream called Jumeaux, which runs diagonally through the garden, and the valley of a river, the Anqueil, which runs across the garden. From the edge of the garden, the stream was channelled underground. The water, in a variety of different forms (pond, a canal, a mirror pond and a fountain) serves as the carrier of the garden composition. In the woods adjoining the site there are several reservoirs filled with water from the stream and other sources, which provide a constant supply of water for the garden. André Le Nôtre, the designer of Vaux-le-Vicomte, made full use of the water-rich environment and the relatively small differences in elevation.

The most imposing element in almost all French gardens is the Grand Canal, a wide body of water that is the central element in the spatial composition. The Grand Canal – the 'la Poêle' basin – is part of the River Anqueil and is located on the lowest level of the site. The river flows through the basin and over the edge (a dam) of the west end, back into the riverbed. On the southern slope of the Grand Canal, near the statue of Hercules, there is a large underground water reservoir that supplies water to the grotto (a protuberance of the canal), fountains and mirror pond between the château and canal. Four watercourses feed into the garden: the stream, the river and two underground water basins. All the water finally converges in the Grand Canal and flows away via the river.

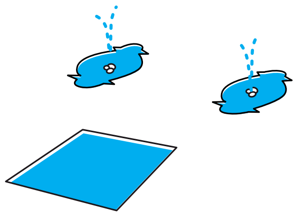
The construction of these ingenious waterworks in this relatively flat landscape was only possible through a careful choice of location and due to the presence and collection of water, the utilisation of the topography, and the underground aqueducts. Purely by channelling the water and making use of the differences in elevation enough pressure is created for the fountains and other water features. In the following section a number of active composition elements are described in greater detail.

Moat and château island
movement: still
form: reflective, framed line of water



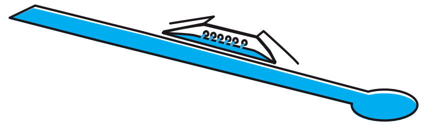
The moat is fed by the stream that has been channelled underground. The water passes through two fountains on the forecourt, then underground again to the edge of the moat, where it falls into the moat by way of jets. The moat creates an island that isolates the château without creating a visual barrier, giving the building a special position in the design.

Mirror pond
movement: still
form: reflective, framed water surface



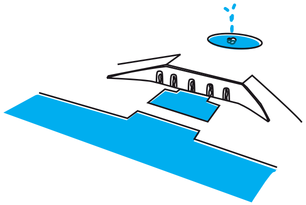
The plan contains several mirror ponds. These are small, shallow, enclosed water basins with a smooth surface. Objects and passers-by are reflected in the water and hence dramatised. The two oval ponds are designed in such a way that, due to the effects of perspective, they appear round when viewed from the building.

Grand Canal
movement: still
form: reflective, framed waterline



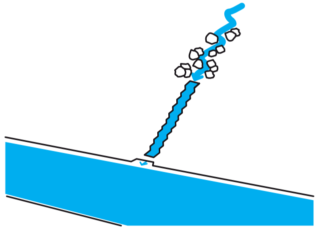
The 2 km-long canal is situated on the lowest level of the site. On the eastern side the axis starts in a large circular basin fed by the Anqueil. On the western side the water flows over the edge of the basin into the depths. The basin is an exhibition of grandeur and was used to stage naval battles. Owing to its immense scale, the axis appears to point to the horizon and is one of the most important organising elements in the garden composition.

Nymphaeum
movement: falling
form: openings in a wall, water element



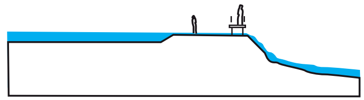
In ancient Greece and Rome, a nymphaeum was a monument dedicated to the nymphs, especially those associated with springs, which was placed in a grotto. The structure is situated on the central axis of the garden, along both sides of the canal. The nymphaeum is an adaptation of the retaining wall that holds back the soil of the southern slope.

Cascade
movement: overflowing, falling and flowing
form: open, channelled and stepped open water surface

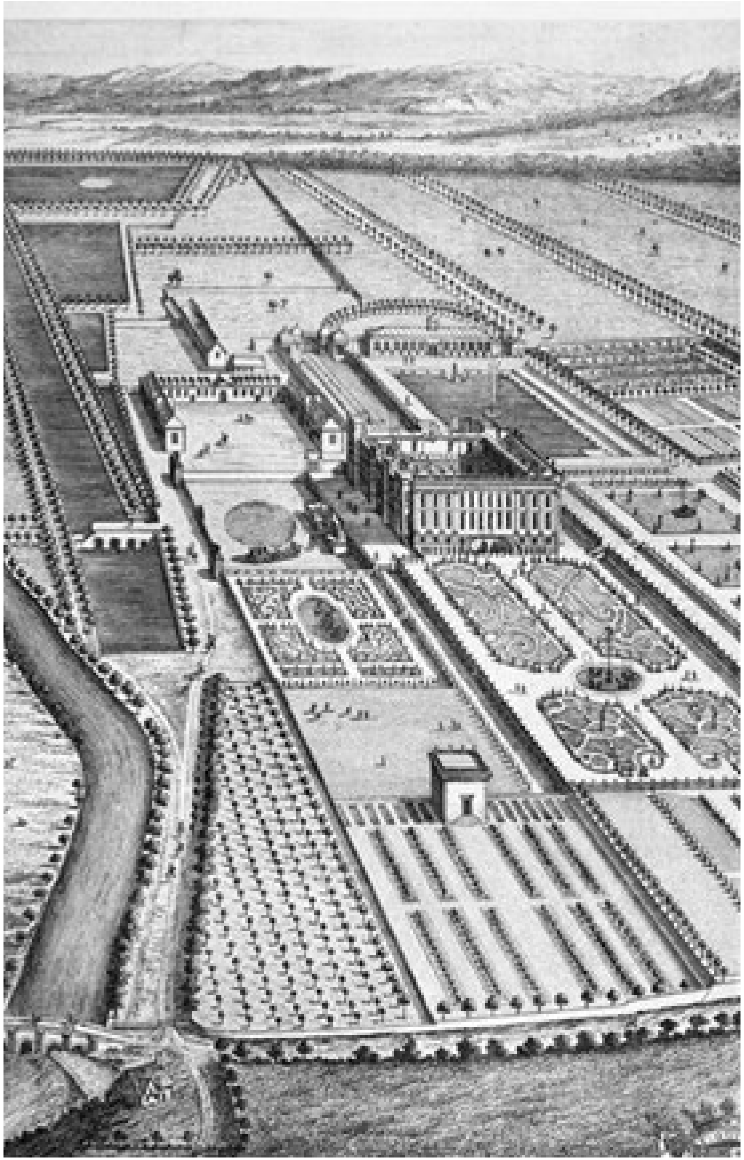


The water of the stream Jumeaux is channelled along the eastern side of the garden by means of an aqueduct. The water rises to the surface just short of the Grand Canal, and flows down a cascade into the basin. The water is aerated as it flows down the steps of the cascade.

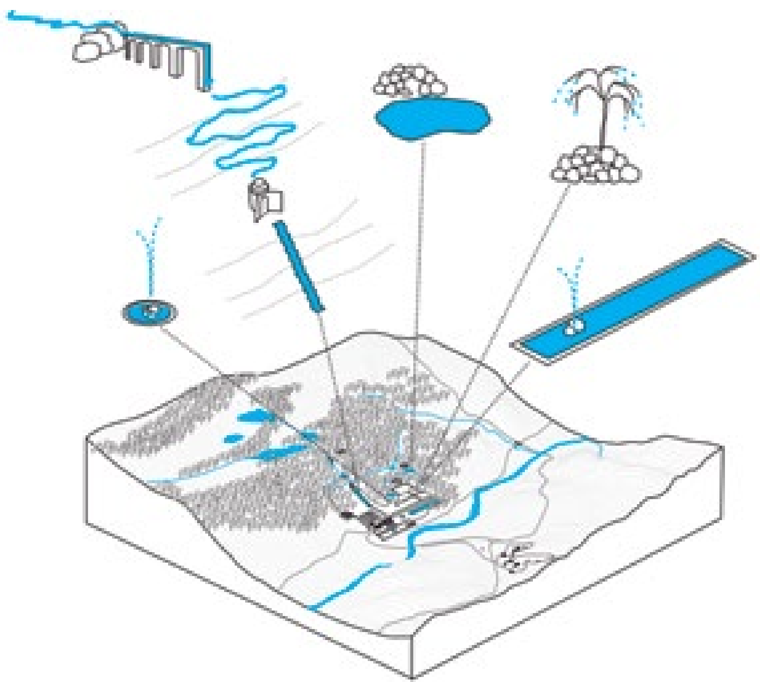
Water bridge and ford
movement: overflowing
form: interrupted water surface



Water can also form a barrier. A natural shallow place where a river can be crossed is known as a ford. At the end of the Grand Canal there is a dam over which water flows out of the garden and back into the river bed. When the water level is high, visitors can use the bridge to cross the canal.



◂ Chatsworth House: engraving and aerial photo



Chatsworth House

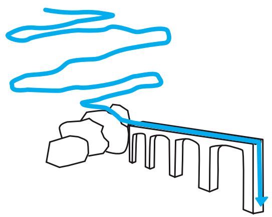
The house and gardens were built from the 17th century onwards in the valley along the steep banks of the River Derwent. Over several decades, many noted landscape architects including Wise, Lancelot 'Capability' Brown and Paxton worked on the design of the gardens. The wet valley area was drained by excavating fish ponds, as can still be seen in the large water basin in front of the house, which is part of the garden design. The water basin is cut into the gently rolling landscape, creating, from the perspective of the house, a vista that extends into the valley. The basin formalises the flatness of the valley.

The basin (Canal Pond) is situated at a level 10 cm higher than the lawn in front of the house. Due to the perspective effect, the surface of the water appears to extend uphill from the southern side. The construction of a monumental fountain in this reflective surface emphasises the steep slope against which Chatsworth is situated. The natural difference in elevation of more than 100 metres allows the water pressure to build up sufficient force to eject the water out of the fountain. Water is channelled from the high plateau to the fountain via a system of pipes with valves that increase the water pressure.

The archetypes of birth, life and death – i.e. the spring, waterfall, river and lake – are symbolised in the garden by the aqueduct, the cascade and the Canal Pond. One discovers all these elements of the water composition while walking through the garden.

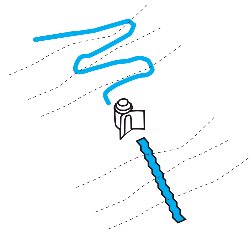
On the East Moor plateau there are extensive wet grasslands. The water level is controlled through drainage. The water is collected in small lakes, reservoirs that supply the water features in the garden. Along the slopes of the site there are three parallel watercourses that graduate from formal to natural, beginning with the aqueduct and its cascade, the waterfall and the grotto with a man-made stream. These watercourses converge on a lower level and supply various water features, such as the Weeping Willow, an artificial tree that spouts water. In the following section a number of visual elements are described in greater detail.

Aqueduct
movement: flowing and falling
form: reflective, high channelled line of water



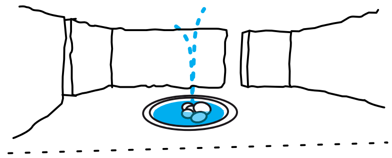
On the edge of East Moor there is a free-standing aqueduct that incorporates the plateau landscape in the garden. Only the column of water is visible from the valley. The freestanding element is an aesthetic adaptation of an aqueduct; a bridge that carries water, bridging valleys or other traffic flows.

Cascade
movement: overflowing, falling and flowing
form: large, channelled and stepped open line of water



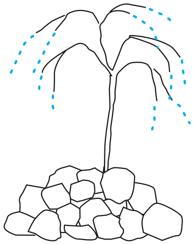
The Cascade consists of 24 steps that vary in length. The edges of the steps are sharply cut, so that the water has a film-like appearance as it flows over them. The cascade is very wide and ends in the axis of the foot-path, which runs perpendicular to the Canal Pond. At the top of the cascade stands the Cascade House with its ingenious system of water jets and surprise elements in the cupola and floor of the building.

Pond
movement: still
form: reflective, enclosed/framed water surface



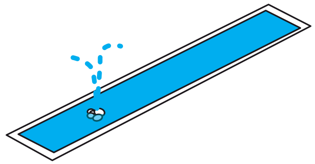
In the extensive parkland of Chatsworth, parallel to the Canal Pond, there are several concealed garden rooms. In the centre of one of the garden rooms, enclosed by hedges, there is a circular pond with stones in the centre of the reflective water surface. This ‘still’ space provides room for reflection, in both a literal and a figurative sense.

Folly
movement: spurting and falling
form: camouflage, fantasy water element



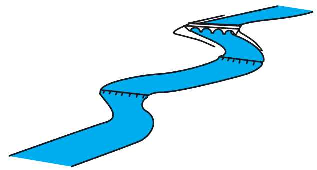
A folly is a building whose purpose is solely ornamental; it is constructed for decorative purposes, as a ‘visual joke’. The garden includes a fountain made from a delicate mesh of copper pipes that look like the twigs of a weeping willow. This bizarre element spouts water in all directions and keeps the surroundings moist.

Canal pond with fountain
movement: still and jets
form: reflective, enclosed water line/surface

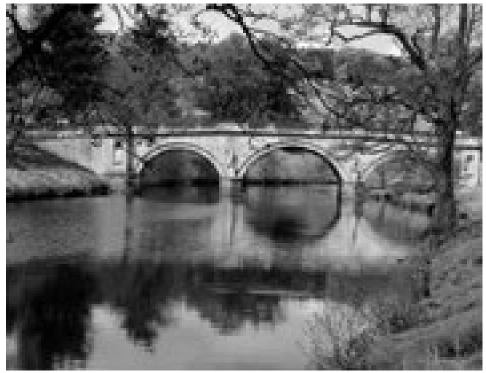


Continuing the line of the house and parallel to the stream, there is a 100-metre-long rectangular basin, set into the slight slope of the site. The basin forms part of the long vista across the valley. On the northern side of the Canal Pond, a fountain sends jets of water 80 metres into the air, possibly due to the immense differences in elevation on the site.

Bridge
form: open, water work, accentuates the meandering line of the water

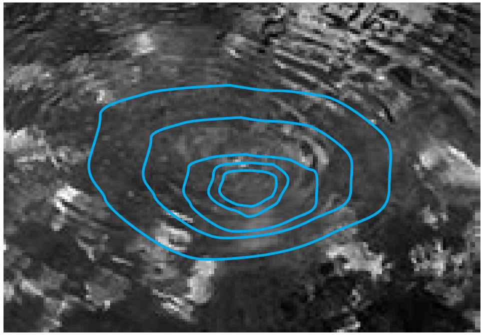


At the point where it flows through the estate the river was widened by way of a weir in order to clearly incorporate the watercourse as an element of the garden composition. The course of the river and its drop were also altered. A new bend on the north-eastern side of the house was marked with a fine bridge, forming the entrance to the site.

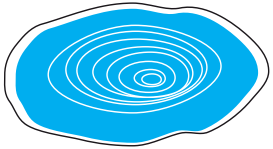


Archetypes

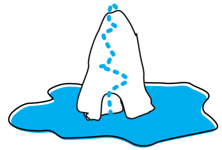
Architectonic water elements



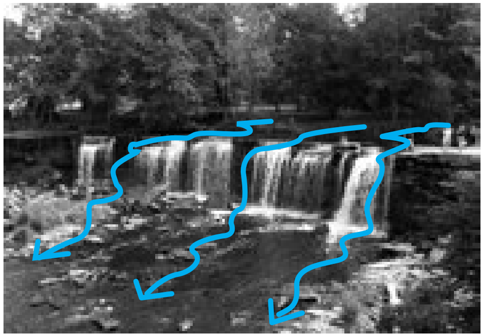
Spring



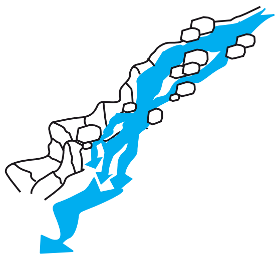
Spring



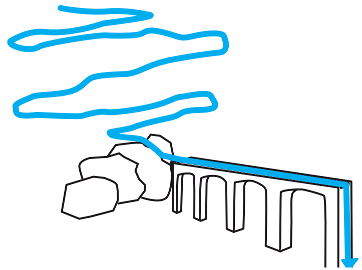
Fountain



Waterfall

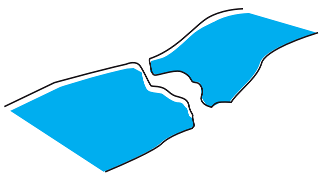


Waterfall

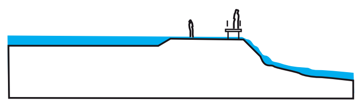


Aqueduct

Ford

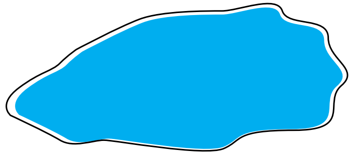


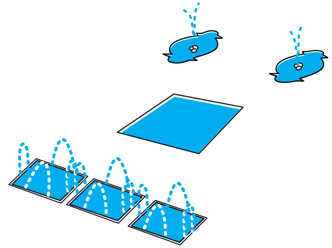
Ford

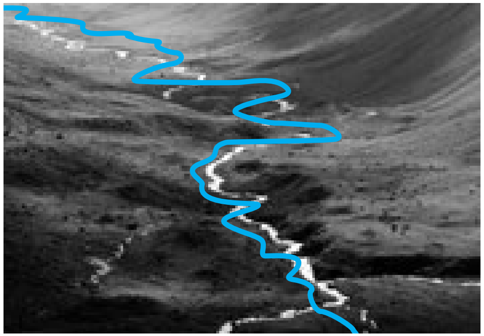


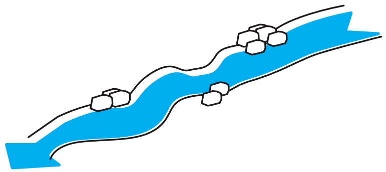
Bridge

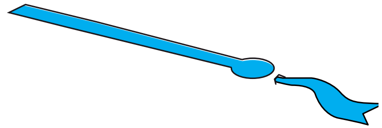

Lake

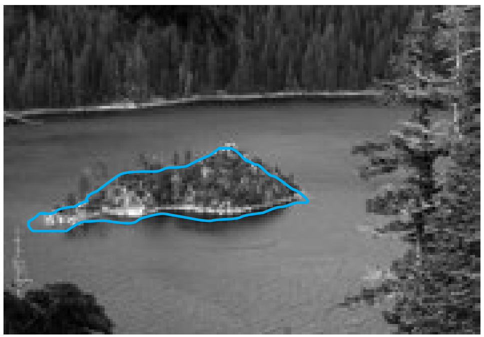

Lake

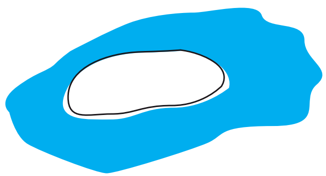

Mirror pond

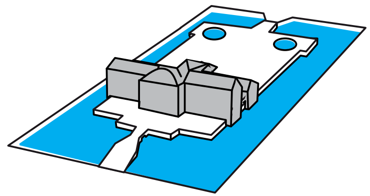

Stream/River

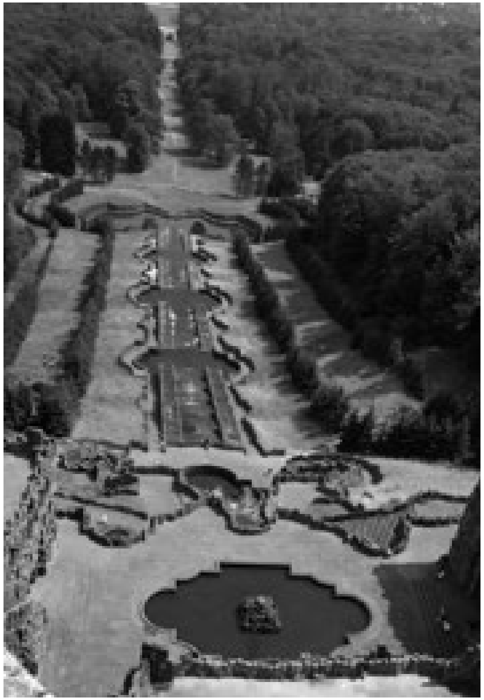

Stream/River


Grand Canal


Island


Island


Castle Moat



◂
Water square in the village of Borssele in the Borsselepolder (NL)

Waterfall, water curtain and cascade in the mountain park of Wilhelmshöhe, Kassel (DE)

Conclusion

A wide range of landscape-architectonic water adaptations has been discussed in the preceding pages. The water in the area surrounding the villa was dammed up off-site, collected and channelled into the garden. Once within the boundaries of the garden, water appears to be the main spatial carrier of the design, and it is transformed by landscape architecture into meaningful water elements, water lines and water surfaces. As soon as the water leaves the site, it resumes its natural course.

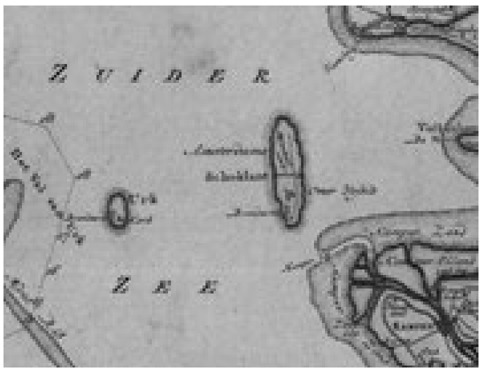
Ultimately, each water feature in the gardens is an adaptation of an archetype taken from unspoiled nature: spring, lake, river, island, waterfall and ford.

A spring is an opening in the ground where the groundwater rises to the surface naturally. A spring is also a symbol of the origin of life. The dimensions of a lake or pool can create and illusion of infinity. If the water is still, the surface becomes a mirror, alluding to inner or reflective knowledge and beauty. A river is a natural, continuous, twisting flow that carries water to lower-lying areas; it symbolises life. An island is land that is surrounded by water on all sides. Owing to its inaccessible character, an island is a microcosm that is associated with paradise, a place of isolation. In a waterfall, water descends from a great height, emphasising the relief in the landscape. The falling water creates sound and can have a cooling effect; it emanates vigour and is continuous. A ford is a connecting element, over or through water that makes it possible to cross to the other side of the water or to make contact with the water. It is an exciting element that may or may not be present from season to season, depending on water levels.

In landscape architecture, the spring is translated into features such as a grotto, nymphaeum, hydraulic organ or fountain; lakes and pools are translated into mirror ponds, fishponds, basins, swimming pools or boating lakes. Landscape architecture translates rivers and streams into a water axis, Grand Canal, moat or rill (water in a gutter), or into a pond in the English landscape style; islands are translated into garden rooms or enclosed gardens; waterfalls into freestanding aqueducts, water columns, cascades or water steps; fords into stepping stones, bridges or dams.

The next chapter will discuss the diversity of water forms to be found in the Dutch Lowlands, followed by mapping the complex mechanism and waterworks of the polder-*boezem* system.

The Netherlands and its water


Z U I D E R
Z E E

The lake-bed polder Beemster.

One of the fortress-ring of the *Stelling* van Amsterdam.

The island of Schokland now positioned in the Noordoostpolder.

The *boezem*-steam pumping station of Wouda.

The mill complex of Kinderdijk in the Alblasserwaard.

Water landscapes

The polder landscapes of the Netherlands, shaped by practical engineering skill and the strong connection between land use and water management, occupy a unique position among the man-made landscapes known to us worldwide. Six of the nine Dutch sites on the UNESCO World Heritage List relate to polders, and therefore to water: the Beemster Polder (a lake-bed polder), Schokland (an island in the Noordoostpolder), the D.F. Wouda Steam Pumping Station, the Stelling van Amsterdam (one of the many defence lines that used water to keep out the enemy), the Kinderdijk mill network in the Alblasserwaard, and the Grachtengordel (the central canal-ring area constructed for drainage purposes in Amsterdam).[1]

They represent the 'Fine Dutch Tradition', in which utility, solidity and beauty merge in design. The Fine Dutch Tradition has its origins in the works of Vitruvius, who expresses the quality of architectonic compositions in his writings using the terms *utilitas, firmitas* and *venustas*. In other words: beauty arises when the various adaptations in a design reinforce each other to create a new, coherent 'mise en scene' (a readable and comprehensible entity), a landscape-architectonic composition.[2] For this reason, and because these objects are irreplaceable and globally unique, they have been designated World Heritage sites.

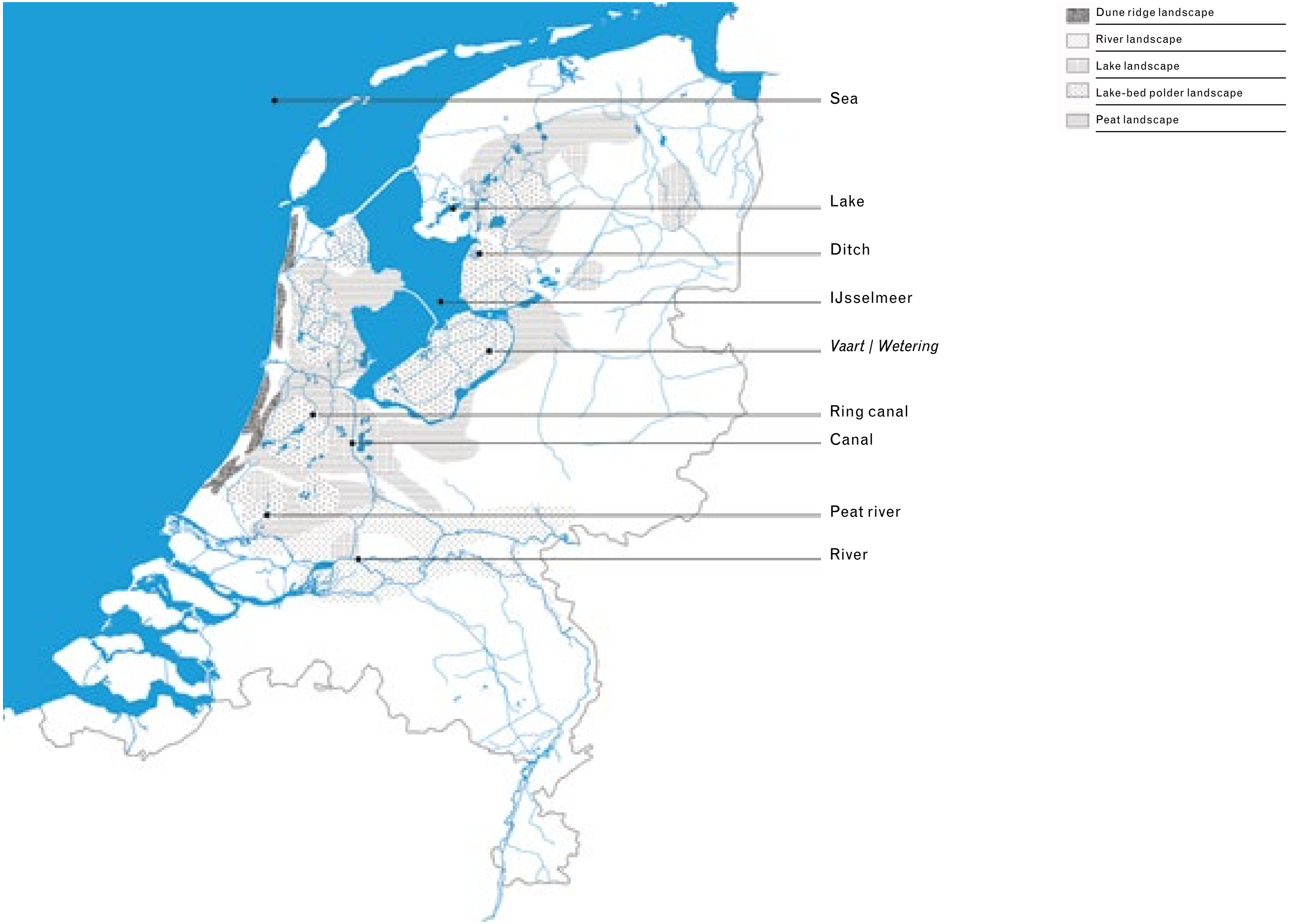
The objects are part of the Dutch polder landscape, which includes many more adaptations of water that are of interest, which will be discussed in this book. From the perspective of the World Heritage List, one could conclude that knowledge of water adaptation has made a genuine contribution to the identity of the polder landscape and of the Dutch city.

The present

Urban, landscape and technological developments in society call for a fundamentally new approach to the planning and structuring of the landscape and the relationship between urban and rural areas. The landscape of the future will have to admit to other configurations than those we see at present. Existing patterns are disintegrating and regrouping in new ways and on a different scale. The necessary changes to the existing water system – the underlying structure of our cultivated landscape – has a considerable influence on the spatial picture of the Dutch delta, with its coast, rivers, polders, infrastructure, towns and villages.

1 Lijn43. (2010). *De Bosatlas van Nederland waterland*. Noordhoff

2 Morgan, M.H. (1960). *Vitruvius: The Ten Books on Architecture.* New York. Courier Dover Publications


Dune ridge landscape
River landscape
Lake landscape
Lake-bed polder landscape
Peat landscape
Sea
Lake
Ditch
IJsselmeer
Vaart / Wetering
Ring canal
Canal
Peat river
River

◂
Map of the Netherlands with an indication of the low lands waterscapes and its water forms.

Locus

In many parts of the Netherlands, the landscape has been shaped by water. Lowland techniques for water drainage, discharge and defences developed out of the need to regulate and stabilise the dynamics of water movements in the delta. Over the centuries, the area of the Dutch Lowlands shrunk as land was inundated by water, then expanded again as land was drained or reclaimed from the sea. The organisation and form of the water system has always had a determining role in the occupation of the landscape. As a result, that which has evolved and that which has been created, the rural and the urban, the natural and the cultivated have become closely interwoven. However; the landscape must not be regarded solely as the result of geographic processes in the past, as a static condition to be preserved, but rather as a dynamic system that is evolving and requires constant attention in terms of design - today perhaps even more so than in the past.

The different forms of water

In the book 'Land inSight' [3] we distinguish between ten types of landscape in the Netherlands. Five of the ten landscapes discussed in the book are lowland water landscapes: sand-ridge landscapes, river landscapes, peat grasslands, lake-bed polder landscapes and lake landscapes. They can be called water landscapes because, on the one hand, the water was the force that drove the development of the landform, and secondly because water is present in large quantities. Each of these landscape types is characterised by a specific water form that is highly recognisable. The water system in the aforementioned landscape types requires constant maintenance and modification in order to ensure that the delta remains inhabitable.

The sand-ridge landscape owes its existence to the sea, which shaped the dunes under the influence of currents, aided by wind-force. Because the coast is under threat from rising sea levels, it needs to be modified. This can be done by way of one or more interventions: by making the existing lines of dunes higher or adding a new one, by widening the beach through sand replenishment, by constructing piers and islands in the sea, or by providing more space for the seawater inland.

In the river landscapes, the water-related problems are very different. Over time, through the diking of the rivers, the amount of room available to the water has shrunk. As a result of deforestation upstream and larger volumes of meltwater in the spring and autumn, the rivers have to carry more

3 Bobbink, I. (2009). *Land inZicht, een landschapsarchitectonische verkenning van de plek.* SUN

water to the sea in a shorter period of time. Numerous plans for dealing with this have been drawn up during the past fifteen years, such as raising the height of the existing dikes, relocating dikes further inland, dredging the rivers, lowering the level of the floodplains, removing obstacles between the dikes and designating emergency polders along the rivers for temporary water storage.[4]

The problems in the lake landscape are due to the quality of the water rather than to increasing volumes of water. The lakes resulted from the extraction of peat, which was used as a fuel from the latter half of the 17th century onwards. The lakes developed where the peat layer was excavated down to below the groundwater level. The extracted peat was laid out to dry on *legakkers*, long narrow islands in the water. The lakes are separated from the surrounding landscape by dikes. Many of the lakes have been drained, but in those that remain a variable water level is maintained. They fulfil an important function as water 'buffers'. As with seawater, it is not the water surface that is designed in lakes, but their banks and the remaining islands (*legakkers*).

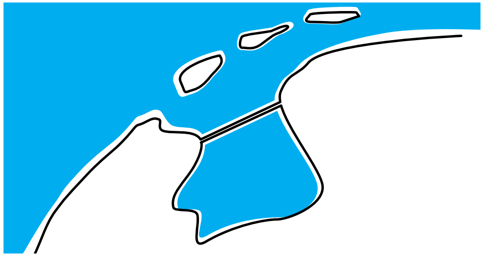
The situation regarding the water in the lowland polders - peat polders and lake-bed polders - is very different. These landscapes are below sea level, and waterworks (e.g. pumps) are needed to remove the rainwater or seepage from the polder. Various lines of water divide the surface of the polder: these are ditches, drainage canals or *tochten* and *vaarten* (two other types of canal), intended to carry away excess water. In a peat polder, the ditches are usually parallel to each other and flow into a wider line of water (drainage canal) that carries the water to a pumping station that discharges the water into the *boezem* system.

In a lake-bed polder (a lake that has been drained, known as a *droogmakerij* in Dutch), the ditches usually form a grid pattern that is connected to wider primary water lines. From here, the water is pumped out in the *boezem* system.

The *boezem* system consists of a network of large, broad water lines (canals, peat rivers, etc.) and lakes on a regional scale. It serves as storage basin and drainage for the excess water from polders and higher grounds and discharges the water into the outer water. Next to the *boezem* there are other waters, which are not part of the *boezem* system such as canals, harbour basins and lakes.

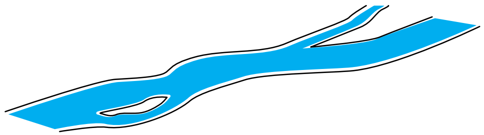
4 www.ruimtevoorderivier.nl

Sea and the IJsselmeer
movement: vertically and horizontally dynamic (tidal)
form: large, rough water surface



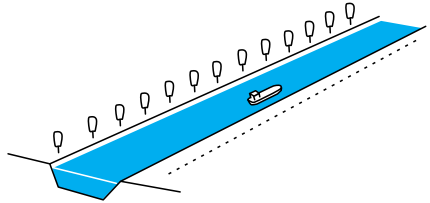
Viewed from the land, the North Sea is a water surface that extends as far as the horizon. The sea is a large body of salt water. The tide turns every 12.5 hours. Due to the construction of the Afsluitdijk causeway in 1953, the IJsselmeer – a salt-water inlet – became a freshwater lake. The coastlines are visible from the lake. Both bodies of water belong to the category outer water (water outside the *boezem* system).

River
movement: flowing
form: large, meandering line of water



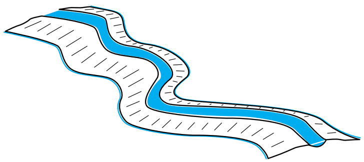
The Netherlands is bisected from east to west by a system of wide rivers, which carry meltwater and rainwater from the hinterland to the sea. The watercourses have been fixed in place by the surrounding dikes. The volume of water carried by the rivers depends on the season: more in the spring and autumn, less in the winter and summer. Rivers belong to the category outer water.

Canal
movement: still and flowing
form: straight, reinforced line of water



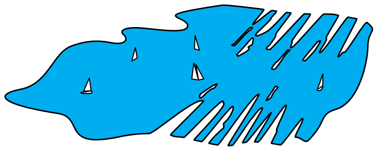
The landscape is divided by two large canals – the North Sea Canal and Amsterdam Rhine Canal, in addition to many small canals. These straight waterways were excavated to transport people and freight, and to carry away water. Canals are part of the *boezem* system.

Peat river
movement: flowing
form: meandering line of water



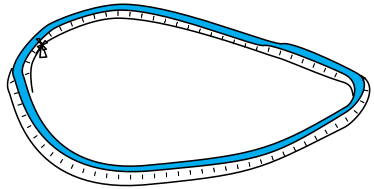
A peat river is a slow-flowing river that begins in a low peatland area and carries away rainwater. The river meanders considerably and now lies at a higher level than the surrounding landscape, owing to the settlement of the peat. At junctions where peat rivers flowed into either a river or another larger body of water (the IJ and IJsselmeer), the 'dam cities' (e.g. Rotterdam) developed. Peat rivers are part of a water network, namely the *boezem* system.

Artificial and natural lakes
movement: still
form: large reflective water surface



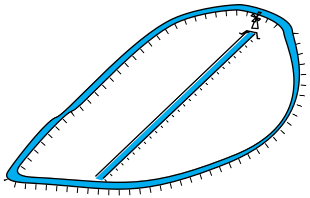
Artificial lakes were created as a result of peat extraction. Since the peat was excavated in lines, the resulting lakes are rectangular and usually contain elongated islands on which the peat was dried. A lake is a large circular water surface resulting from the natural erosion of peat. The artificial and natural lakes in the Dutch lowlands are no more than 2 to 3 metres deep.

Ring canal
movement: still and flowing
form: ring of water



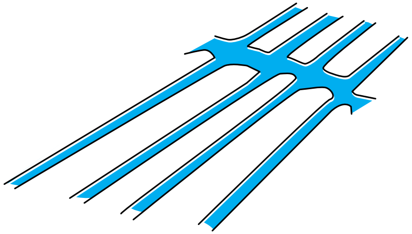
A ring canal is a ring-shaped canal around a lake-bed polder. Water is pumped into the ring canal from the polder. Ring canals are part of the *boezem* system, which discharges the polder water.

Watercourses (*wetering, vaart* or *tocht*)
movement: still and flowing
form: slightly meandering or straight line of water

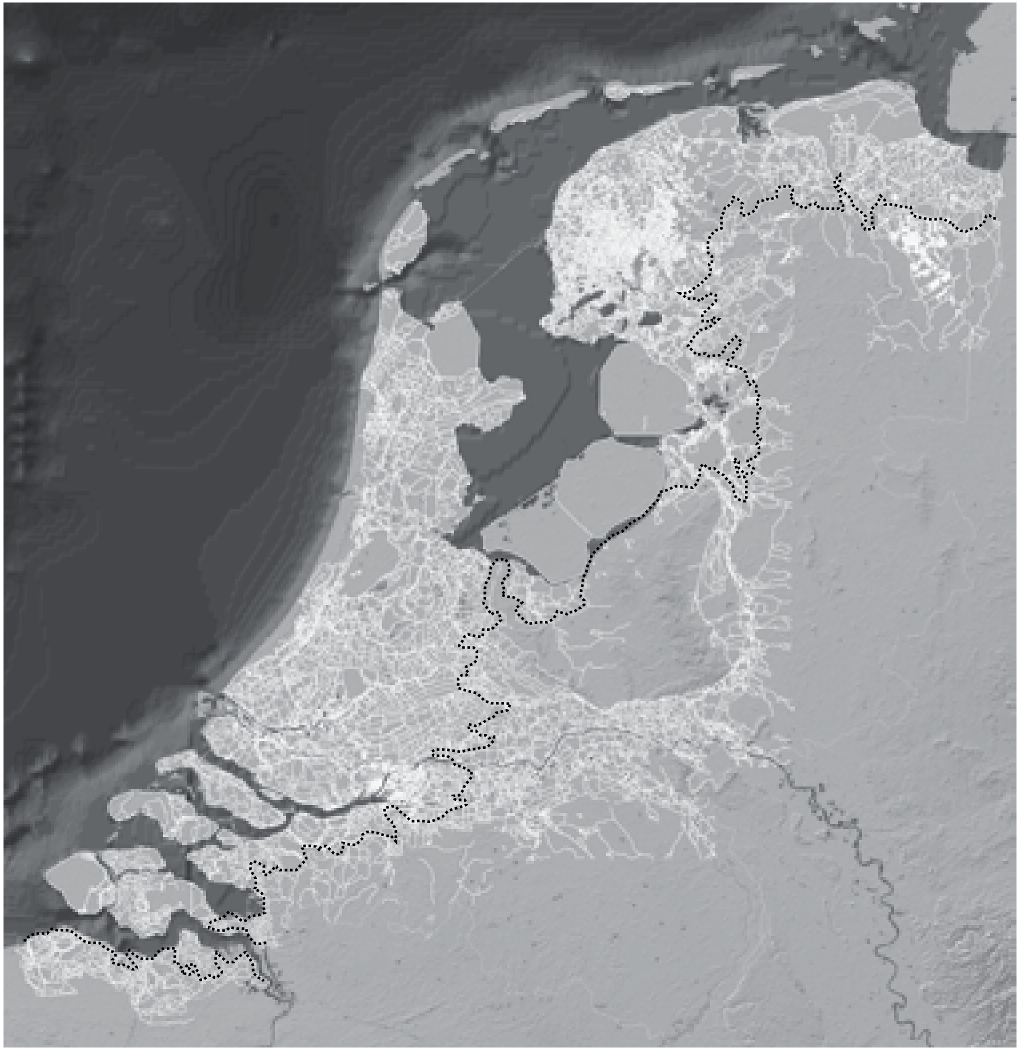


These are excavated, wide, straight waterways, usually on a level with the polder. In the peat polder a *wetering* was excavated parallel to the reclamation base. Ditches discharged water into these watercourses. In lake-bed polders, the wide straight watercourses into which the ditches discharge are called *vaarten* or *tochten*. They are part of the polder-water system and, by means of a pumping station, carry the water to the *boezem*, which is on a higher level. There are also *vaarten* at *boezem* level.

Ditch
movement: still and flowing
form: narrow line of water



A ditch is the most common repeating linear water element, with the purpose of allowing water to drain away. A peat ditch is, on average, 2.5 m wide and 60 cm deep, and the water level is just below ground level. A ditch in a lake-bed polder lake appears narrower than a ditch in a peat polder because it is further below ground level and is therefore less visible.



Altitude + 0 NAP

25 km

The polder map of the Netherlands including the 0 NAP-line.

The measuring platforms (*meetstoelen*) were used as viewing and reference points for the layout of the polder.

Polder map

The Netherlands incorporates 3,891 polders, most which would fill up like a bathtub if they were not drained. A polder is taken to mean an area of land surrounded by water defences (dikes, embankments or natural relief), with controlled water levels. In each polder, the water level is set independently of the surrounding area. In most cases this is done mechanically by a range of waterworks (weirs and pumping stations).

Based on soil differences, we distinguish two types of polder: peat polders and lake-bed polders. The main difference between the two types relates to agricultural use: peat polders consist mainly of grassland; a lake-bed polder is more suited to crops. Most of the polders in the west of the Netherlands are below Amsterdam Ordnance Datum (*Normaal Amsterdams Peil*, NAP) [5], the reference level in the Netherlands, which corresponds approximately to the mean sea level. The zero level of NAP is indicated on the map by way of a dotted line. Over the centuries, the polders have been wrested one by one from the bogs and the sea, and enclosed by kilometres of dikes, within which there are thousands of kilometres of ditches.

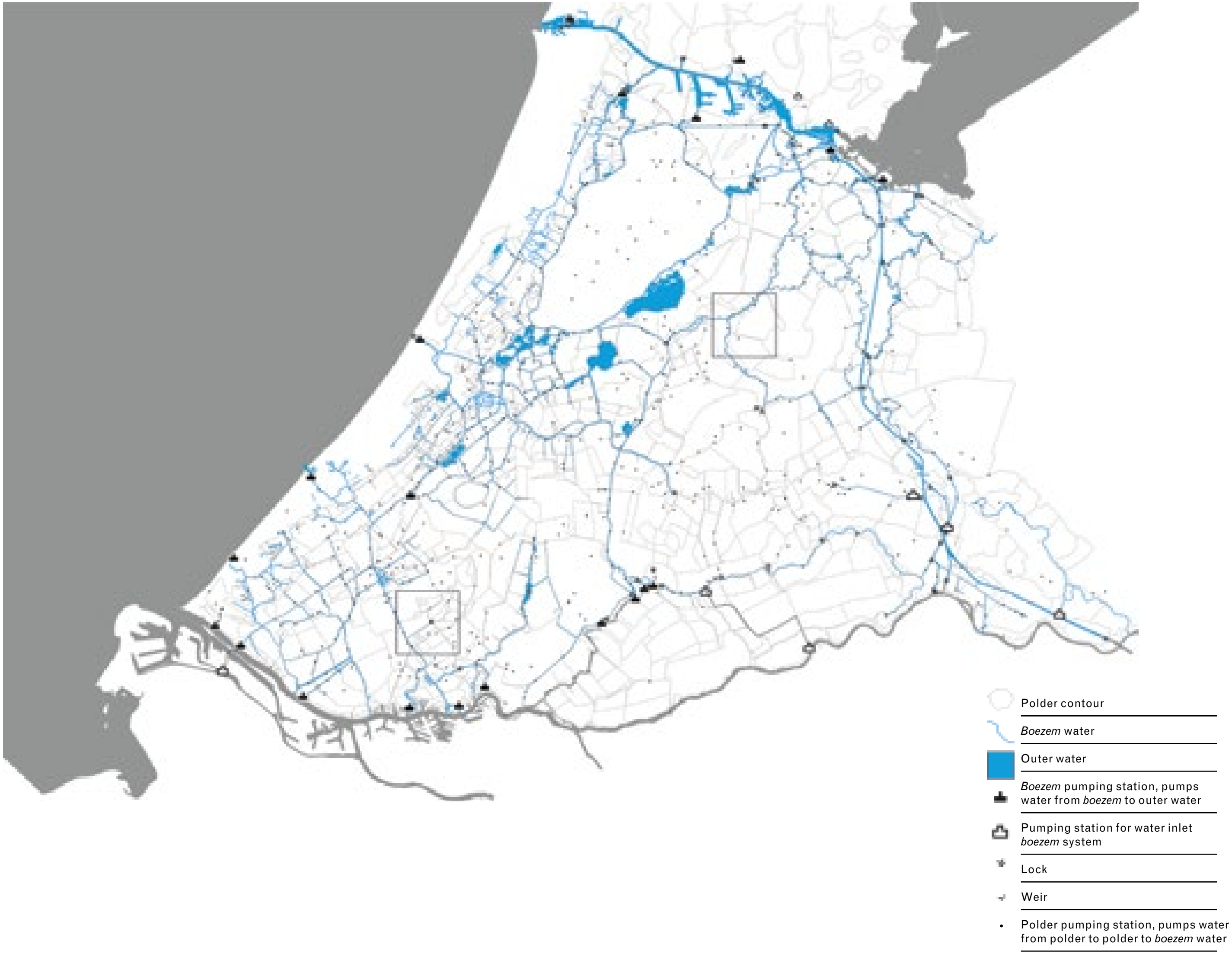
The polders as a built structure

From a landscape-architectonic point of view, a polder could be described in spatial terms as a constructed landscape [6] a 'building' with rooms that remains intact with the help of dikes (the walls). The rooms vary in terms of their dimensions, depth, shape and use. Alongside the dozens of small, narrow, elongated polders that lie parallel to the rivers, what stands out in the drawing are the larger polders that are more often square or circular in shape. These are the most recently reclaimed polders (lake-bed polders), such as the IJsselmeerpolder, which was reclaimed from the IJsselmeer after the construction of the Aflsluitdijk causeway in 1932. These are much larger than the older polders because, when steam- and electric-powered pumping stations were introduced at the beginning of the 20th century, a single pumping-station could drain a much larger area of land. In order to drain parts of the IJsselmeer, dikes were constructed in the water. Once the compartment was encircled by dikes, the water could be pumped out. The level of the polder surface was measured off using measuring platforms (*meetstoelen*) that were installed in the mud, and the ditches and vaarten were then excavated. Some of the measuring platforms have remained (e.g in the Noordoost polder), as silent witnesses to the 'poldering' process: their height indicates the water level of the IJsselmeer.

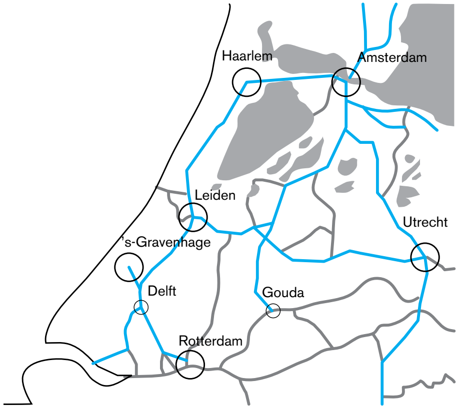
5 N.A.P.: Normaal Amsterdams Peil

6 Steenbergen, C., et al. (2010). *The Polderatlas of the Nederland.* Birkhäuser

Boezem map



Polder contour
Boezem water
Outer water
Boezem pumping station, pumps water from *boezem* to outer water
Pumping station for water inlet *boezem* system
Lock
Weir
Polder pumping station, pumps water from polder to polder to *boezem* water



▲ Map of the barge-canal system: Which was used in the 17th century as a transport system for goods and people. It still fairly correspondence with today's *boezem* system.

◀ Map of the *boezem*: Composed out of the poldermap of the Dutch Lowlands containing the *boezem* en its pumping stations located on the boarder between *boezem* and the water outside. The frames mark two zooms to be seen on page 50.

The *boezem* system

In order to discharge the water from a polder, the *boezem* system is usually used as an intermediate step. A *boezem* is a system of watercourses that is separated from the adjoining polder land by means of dikes and embankments, and also from the water outside by way of drainage sluices or pumping stations. Excess water collects in the *boezem* and is released outside the *boezem* system as necessary. During dry periods, water can be released from the *boezem* into the polder. The water-storage capacity depends on the surface area of the *boezem* and the height of the embankments or dikes that enclose it.[7]

The *boezem* system is more or less at the ground level from before the period of intensive reclamation, 1,000 years ago, and comprises old river tributaries, peat rivers, ring canals, excavated canals, lakes and *boezem* land.

In some places there is a low *boezem* (*lage boezem*) that mediates between the main (high) *boezem* and the polder. The water level in this system is higher than that of the polder, and lower than that of the high *boezem* system. The low *boezem* is connected to the high *boezem* and the polder by pumping stations and/or sluices. The low *boezems* are not shown on the map. The low *boezem* system also contains ring canals, canals and open water (lakes), for example the Voor- and Achterplas in Rotterdam.

The barge-canal system

In the 17th century, parts of the main *boezem* system in the provinces of Holland, Utrecht, Friesland and Groningen belonged to the *trekvaart* (barge-canal) system, an ingenious public-transport system over water that operated to a timetable. The barges were towed by horse, which made their way along the towpaths running alongside the canal. The water network was used not only to transport passengers, but also to transport goods, and was also used by ferry services and market barges. In 1765, some 800 service barges (*beurtschepen*) and market barges sailed out of Amsterdam every week to 180 different destinations.[8] With the rise of roads and railways from the beginning of the 19th century onwards, this water system lost its function as a transport network. Its only function after this period was that of a drainage system for the polder water and for water storage. Interest in the navigable waterways revived from the 1980s onwards with the rise of recreational boating. More and more connecting waterways were reopened, and new ones were even excavated.

7 Rijn, D. van, Polderman, R. (2010). *Het water de baas.* Hilversum

8 Vries, J. de (1981). *Barges & Capitalism, Passenger Transportation in the Dutch Economy (1632-1839).* Utrecht

◂

Boezem-pumping stations Lely in de Wieringermeerpolder

Polder-pumping station Cruquius in de Haarlemmermeerpolder

Polder-pumping stations Noord-Kethelpolder langs de Schie

Boezem-pumping stations Westland on de Nieuwe Waterweg

Polder-pumping station Stein-Oudorp

Polder-pumping station Binnenwegse Polder

Boezem and polder pumping station

Pumping stations pump the water from the *boezem* to the water outside the system – the main rivers, the IJsselmeer and the sea. The pumping stations are large and have a capacity of more than 1000 m³/min. There are also pumping stations that pump water from one *boezem* to another, if there is no connection to the water outside, and combined pumping stations that can serve a polders as well as a *boezem*.

Some *boezem* pumping stations also function as an inlet that lets fresh water from outside into the *boezem*, thus providing extra water for the polder in dry periods. On 18 May 2011, for example, due to the persistent lack of rain, two inlet pumps were brought into operation, one on the Lek and one on the Amsterdam-Rhine canal, near Utrecht. These installations pumped fresh water into the *boezem* system in the central Netherlands in order to flush out the polder water. The aim of the water board (Regional Water Authority) was to prevent salinisation of the water in the polders as a result of the drought. In a number of locations, drainage sluices have been built in addition to the *boezem* pumping station, so that *boezem* water can flow out through the effects of gravity when the level of the water outside is low. IJmuiden is home to the largest *boezem* pumping station, with a capacity of 15,600 m³/min.

In addition to the dozens of *boezem* pumping stations in the Netherlands, there are approximately 4,500 polder-pumping stations[9]. Polder-pumping stations pump water from the polder – sometimes via a low *boezem* – into another polder, into the *boezem* or directly into the water outside the *boezem* system. The smallest pumping stations (*onderbemaling*) are positioned in the polder and pump water from a lower to a higher level. They have a capacity of 1.0 m³/min to 25 m³/min.

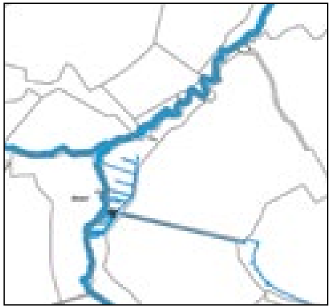
The polder-*boezem* system

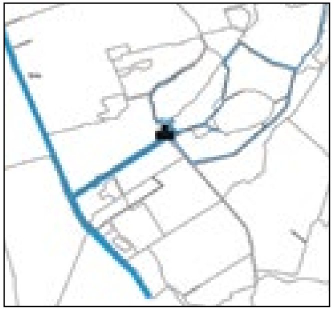
The water in the polder-*boezem* system can move to either a higher or lower level, e.g. downward from one decreed water level to the next through weirs or upwards, being pumped from a low *boezem* to a high *boezem*. The most characteristic feature of a polder-*boezem* system is that water from the polder has to be pumped to a higher level and discharged outside the system via the *boezem*.[10] The following drainage courses, listed in order of size (small to large), are part of the polder-*boezem* system:

- from a lower water-level area, via a *peilvak*, via a polder, to the water outside;
- from a lower water-level area, via a *peilvak*, via a polder, via a *boezem*, to the water outside;
- from a lower water-level area, via a *peilvak*, via a polder,, via an interlinking *boezem*, via a *boezem*, to the water outside;
- from a lower water-level area, via a *peilvak*, via a polder, via an inner *boezem*, via a polder, via a low *boezem*, via a high *boezem*, to the water outside.

9 Grondmij study, 2008

10 Danner, H.S., Rijswijk, B. van, et al. (2009). *Polderlands, Glossarium van waterstaatstermen.* Stichting Uitgeverij Noord-Holland, Wormerveer Informatie Desk Standaarden *Water Aquo-lex (versie 10)* http://www.idsw.nl/aquo-standaard/aquo-lex/ Waterwet, Hoofdstuk 1 Algemene bepalingen, Paragraaf 1 Begripsbepalingen, Artikel 1.1 http://wetten.overheid.nl/BWBR00254





Detailed map of the Ronde Venen polder complex showing the River Amstel as *boezem* at the edge of the complex, the adjoining *boezem* area and the slightly lower-lying interlinking *boezem*. Between the River Amstel and the interlinking *boezem* is a lock. The interlinking *boezem* is situated on the old peatland and separates two polders.

Detailed map of the Schie Canal between Rotterdam and Delft. The *boezem*, the canal has a long side branch at *boezem* level from which the Berkel interlinking *boezem* system drains via a pumping station.

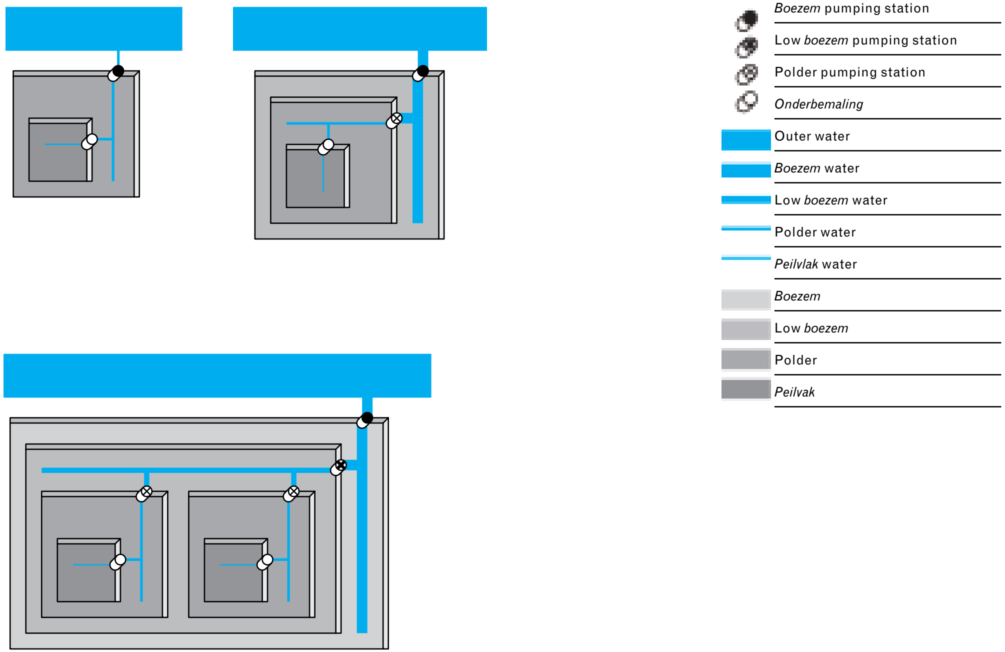


Diagram showing the increasing complexity of drainage in the polder-*boezem* system. How all the individual parts of the system work, is explained on the next page.

Onderbemaling (low water-level area)
location: in the polder
An *onderbemaling*, or a low water-level area is a zone (it can also be a single ditch) with a lower water level with one (usually) or more drainage points in a *peilvak* (a fixed water-level area in the polder). Users of the area, mainly farmers set the water level in the *onderbemaling*.

Peilvak (a fixed water-level area in the polder)
location: part of one or more polder(s)
A fixed water-level area is a closed system of watercourses with a specific water level, with one (usually) or more discharge points into other water-level areas or into the inner *boezem* and/or the low *boezem* and/or the water outside the *boezem* system. A *peilvak* can correspond to a polder, but is usually part of it. The fixed water level of a *peilvak* is set by the water board and documented in a water-level decree.

Polder section
location: part of one or more polder(s)
A polder section is a closed system of watercourses, with a specific water level, with one or more outlets into another polder section or into the *boezem* system. A polder section is designated by the water board and occurs only in large polders. In fact it is very similar to a *peilvak*.

Polder
A polder is a system of one or more linked water-level areas with one or more drainage points into a low *boezem* and/or a high *boezem* and/or the water outside the *boezem* system. The water management of a polder is separated from the surrounding hydrological regime. Within the polder there are often some low-lying water-level areas (*onderbemaling*). Many polders consist of more than one *peilvak* or polder sections. The water board specified the water levels of a polder in a water-level decree.

Inner _boezem_
location: in the polder
Inner *boezems* only exist within polders. The polder water is first pumped into the inner *boezem* before it is carried to the *boezem* system. An inner *boezem* is an extra link in the system that ‘mediates’ between the polder and the *boezem*. Inner *boezems* only exist in lake-bed polders.

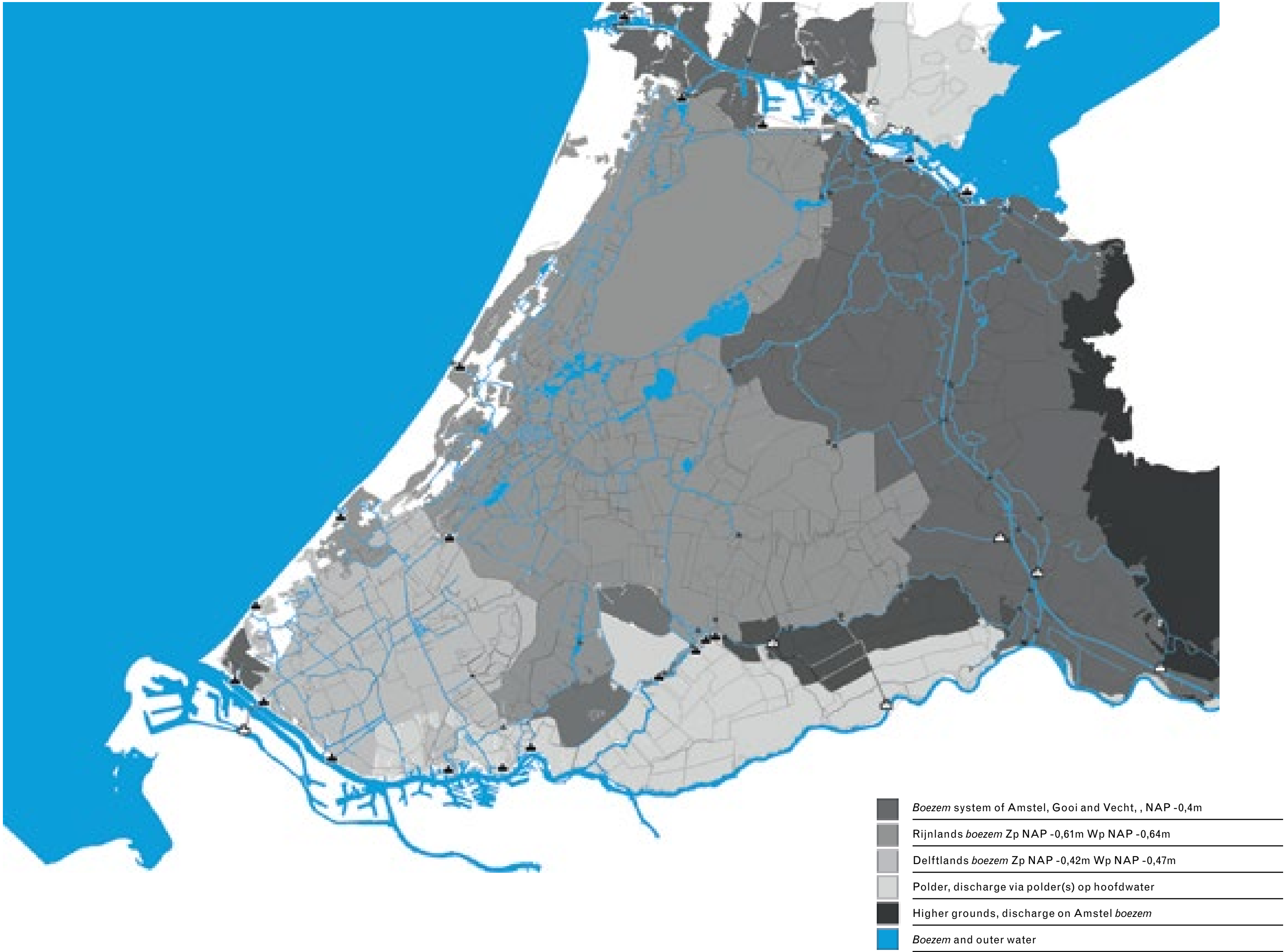
Low _boezem_
location: between polders
An low *boezem* is a closed system of a watercourse into which water from polders and *peilvakken* drains before the water is discharged into the *boezem*. A low *boezem* is an extra link in the system that ‘mediates’ between the polder and the high *boezem*. A low *boezem* can take a variety of forms: a ring canal, canal, river, peat river or lake.

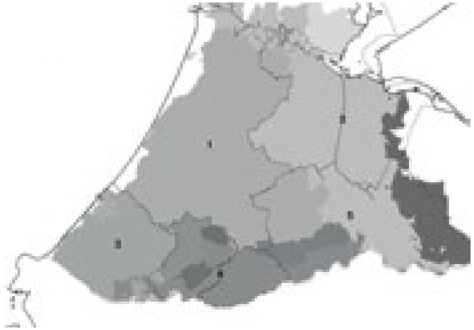
High _boezem_
location: between polders
A *boezem* is a closed system of watercourses into which water from polders, inner *boezems* and low *boezems* drains before it is pumped or drained outside the system. The main function of a *boezem* is to drain excess water from the polder, but also to store and supply the water. A *boezem* can take a variety of forms: a ring canal, canal, peat river or lake.

Boezem land or _vlietland_
location: at the level of the *boezem*
A *vlietland* is land between the *boezem* and the *boezem's* banks that is flooded when water levels are high.
Boezem land is non-reclaimed land with a high elevation that drains naturally into the *boezem* without the need for pumps. *Boezem* land increases the storage capacity of the *boezem*. *Boezem* land is situated in old peat-lands, next to sand ridges or in other higher areas on the edge of polders.

Uplands
location: just below the level of the *boezem*
Uplands are elevated areas of land, where no peat has been extracted, between a *boezem* and a natural lake or a lake-bed polder. The surface level of uplands has usually sunk considerably, to (just above) the level of other peat polders. It is usually between -1 and -2m in relation to the Amsterdam Ordnance Datum (NAP).

Outer water
location: at the end of a discharge system
Outer water includes the sea, the IJsselmeer, the main rivers and any bodies of water connected to the sea that is not subject to water-level management. The Directorate-General for Public Works and Water Management regards the IJsselmeer as outer water, although it is no longer directly connected to the sea.


Boezem system of Amstel, Gooi and Vecht, , NAP -0,4m
Rijnlands *boezem* Zp NAP -0,61m Wp NAP -0,64m
Delftlands *boezem* Zp NAP -0,42m Wp NAP -0,47m
Polder, discharge via polder(s) op hoofdwater
Higher grounds, discharge on Amstel *boezem*
Boezem and outer water



Boezem map in relation to the various drainage and *boezem* areas, distinguished by various shades of grey.

The small map at the top of the page shows a projection of the contours of the present-day water board districts (in dotted lines) on the drainage areas. The boundaries of the water board districts do not correspond to the drainage areas.

1. Water board of Rijnland (South-Holland en North-Holland)
2. Water board of Amstel, Gooi en Vecht (North-Holland, Utrecht en South-Holland)
3. Water board of Delfland (South-Holland)
4. Water board of Schieland and Krimpenerwaard (South-Holland)
5. Water board of De Stichtse Rijnlanden (Utrecht en South-Holland)

Drainage area / *boezem* area

In a low-lying polder landscape, it is not so appropriate to use the term catchment, the original word for a drainage area. This term assumes that an area drains naturally through the effects of gravity, as was originally the case in the Dutch lowlands. As a result of settlement and peat excavation, water no longer drains away naturally in the polder landscape. Pumps and sluices are needed to bring the water to the right place. In the Randstad conurbation it is therefore more appropriate to use the term *boezem* area (*boezemgebied*) rather than drainage area (*afwateringsgebied*). A *boezem* area is an area that is separated from surrounding water and discharges polder water at one or more points. In the *boezem* area, the water is discharged through pumping stations at the edges of the area. Due to the watersheds, probably as a result of the landscape relief or the suction of the pumps, watercourses in close proximity to each other may be part of different catchment or drainage areas. The map clearly shows that the *boezem* areas vary considerably in size and scale, probably as a result of the original relief of the peat bogs.

The water board (Regional Water Authorities)

A water board (*waterschap or hoogheemraadschap*) is a Regional Water Authority responsible for water management in a particular region in the Netherlands. The term *waterschap* also denotes the area over which the body holds authority. [11] The size and boundaries of the area are not determined by municipal or provincial boundaries, and only partly by *boezem* or drainage areas in a given region. The boundaries have evolved over time. There are currently 25 water boards in the Netherlands – a manageable number, given that there used to be hundreds.

Water boards were formed ad hoc, as and when a hydraulic-engineering problem arose, such as the need to build a new dike or sluice. The next time a problem arose, new regulations were drawn up and another authority was formed.[12]

Water boards are among the oldest institutions belonging to the Dutch system of government, as we know from sources dating back to the 12th century. They are elected by the area's residents and are responsible for water management. The need for community-based water management has shaped the land and its people over many centuries and is part of Dutch culture.

11 http://almanak.overheid.nl/categorie/32/Waterschappen/

12 http://www.waterschappen.nl/ontdekde-waterschappen.html

2 km

2 km

◂ The topographical maps 1894 and 2009 clearly show the changes resulting from the land reallocation policy adopted in the Hensbroek polder by the Province of North-Holland. Up until the middle of the 20th century the individual plots of land could only be reached by boat.

▴ Aerial photo of a sailing polder

Land consolidation

A landscape is not static; it is constantly evolving and subject to change. It does not make a great deal of difference whether the landscape concerned has been subjected to limited human influence or whether – as in the case of the Dutch polder landscape – it is a man-made landscape. There is a symbiotic relationship between the image of our polder landscape and the function and use of the land.[13] The drainage of the bog landscape initiated an irreversible process that will always require monitoring and modification.

The introduction of the Land Consolidation Act (*Ruilverkavelingswet*) in 1924 laid the foundation for an organised restructuring of the landscape that would take at least seventy years.[14] During this period, more than half the land in the Netherlands was repartitioned and consolidated, initially with the aim of increasing agricultural production. Plots of land were merged through exchanges, and farms and access roads were relocated. Ditches and other watercourses were rationalised, removed or optimised. As this process went on and progressive insight was gained, the scope of the Land Consolidation Act was broadened so that other spatial and ecological aspects apart from agricultural efficiency were incorporated in the restructuring.

Half a century of land consolidation and rural land-use planning has had a less visible impact on the peat meadow areas than elsewhere. The landscape planning for the peat polders focused mainly on preservation; the image of the landscape was characterised by panoramic vistas and the reflection of the sky and clouds in the water. The openness of the area was seen as a great benefit, and the mediaeval pattern of land division in small plots was therefore preserved. It was not easy to change the pattern of reclamation in a peat grassland polder but, despite this, farms were relocated, navigable polders became extremely rare, and considerable numbers of ditches were filled in or redirected.[15] So even though the appearance of the polder may not have changed, its use has.

The polder as a sponge

Until the 1950s, large parts of the Dutch Lowlands were inundated for long periods during the winter. The west of the Netherlands was an enormous sponge that could hold enormous volumes of water during the wettest six months of the year. Through modernisation, this sponge has been radically removed, among other things by setting fixed winter and summer water levels on a much deeper drainage base. The lower water levels prevent the roots of crops from rotting, and make it possible for hay to be harvested several times a year. Agriculture owes its success to these changes but, as a result of urban expansion and pumping being carried out at greater depths, the capacity for temporary water storage has been completely lost.[16]

13 Sijmons, D. (2002). *Landkaartmos.* Uitgeverij 010

14 Visser, R. de (1997). *Een halve eeuw landschapsbouw, Het landschap van de landinriching.* Uitgeverij Blauwdruk

15 Stroeken, F., Wit, J. de, Brink, M. (2009). *Royal Haskoning rapport, Waarheen met het veen?* Stichting leven met water

16 Bureau H+N+S. (2005). *Pleidooi voor waterrijk handelen,* 2e editie. Architectuur Biënnale Rotterdam

2 km

2 km

Sections of the Amsterdam-South-East water management map from 1850 and 1884.

The map shows the various polders, each with their own water level: low in the winter and high in the summer. The building up of this area has brought many changes, as polders are now broken up into various water-level areas. In the urban expansion area the water patterns have changed completely.

The *waterschap* map

In the map all the different water levels and water flows are recorded. The artificially maintained water level is determined in relation to the ground level of the land. The effects of ground shrinking are more obvious in a peat polder than in a lake-bed polder because peat becomes more strongly compressed and partly decomposes after water is drained away. In order to prevent further shrinking of the peat, water levels in the peat areas are raised, i.e. brought closer to the ground level.

The water level in a lake-bed polder is on average 40 to 70 cm below ground level. This ensures that the crop roots do not become waterlogged. The water level varies with the seasons. In the winter it is higher, because very little water evaporates. During a dry summer, such a large amount of water evaporates that it has to be replaced with water from the *boezem* system. The whole water system can be set in motion by switching the pumping stations on and off, or by turning them in another direction.

In urban areas in particular, the water system has become very complex. Between 1992 and 2002, the number of decreed water-level areas doubled. Consequently, more waterworks are needed, management has become more complicated, and costs have increased.

Climate change

At the beginning of this century, after a number of near-dike breaches occurred in the river region in 1993 and 1995, it became clear that it was time to radically review the existing water-management system. Flooding was attributed to climate change and scientists became increasingly convinced that several water-related issues would require more attention in the future. The authors of the book 'More Urban Water'[17] identify nine problems affecting the water system. We should anticipate a shift in the tectonic plate (1), which is expected to cause the land in the west of the Netherlands to sink to 10 m below sea level over a period of 100 years. Mean temperature will increase (2), as will the sea level (3). Precipitation will increase (4) and increasingly heavy rain showers will generate more water in shorter periods (5). The land is settling more and more as a result of drainage – by means of ditches, but also underground pipes that are usually not visible and draw water out of the soil (6). In the deep polders there is salty seepage (7) that is threatening the survival of common plants. As a result of surfacing and paving, especially in urban areas (8), water can no longer soak away into the soil. Finally, water is becoming increasingly polluted (9) due to agriculture and population growth. Not all these problems relate directly to polder water, but they do involve the water regime in the Netherlands as a whole.

New insights call for new policy, which was formulated with great urgency in 2003. The main principle of water-management

17 Hooimijer, F., Toorn Vrijthoff, W. van der (2010). *More Urban Water: Design and Management of Dutch Water Cities*. Taylorand Francis/ Balkema

In the past, in order to protect cities polders were flooded to obstruct the enemy. A similar picture of inundated land can now emerge after a period of prolonged rain when the *boezem* is unable to store the volume of water. Ruigenhoekse polder 1926-NI institute of military history, Den Haag

In recent years showers are sometimes so heavy that the existing pumps are unable to cope with the volume of water. This problem is aggravated in the hard-surfaced urban areas.

The volume of uncontrolled water means that flooding in the rivers region can cause enormous damage to agricultural land and built-up areas.

In 2003 an entire housing estate in the Ronde Venen in Wilnis was flooded when a dike shifted. The dike of the interlinking *boezem* was weakened as a result of drought and a low water level, resulting in a break. To prevent them from drying out, in many places dikes are checked daily and sprayed where necessary to keep them sufficiently moist.

18 Nationaal Bestuursakkoord Water (NBW) 2003

19 www.helpdeskwater.nl

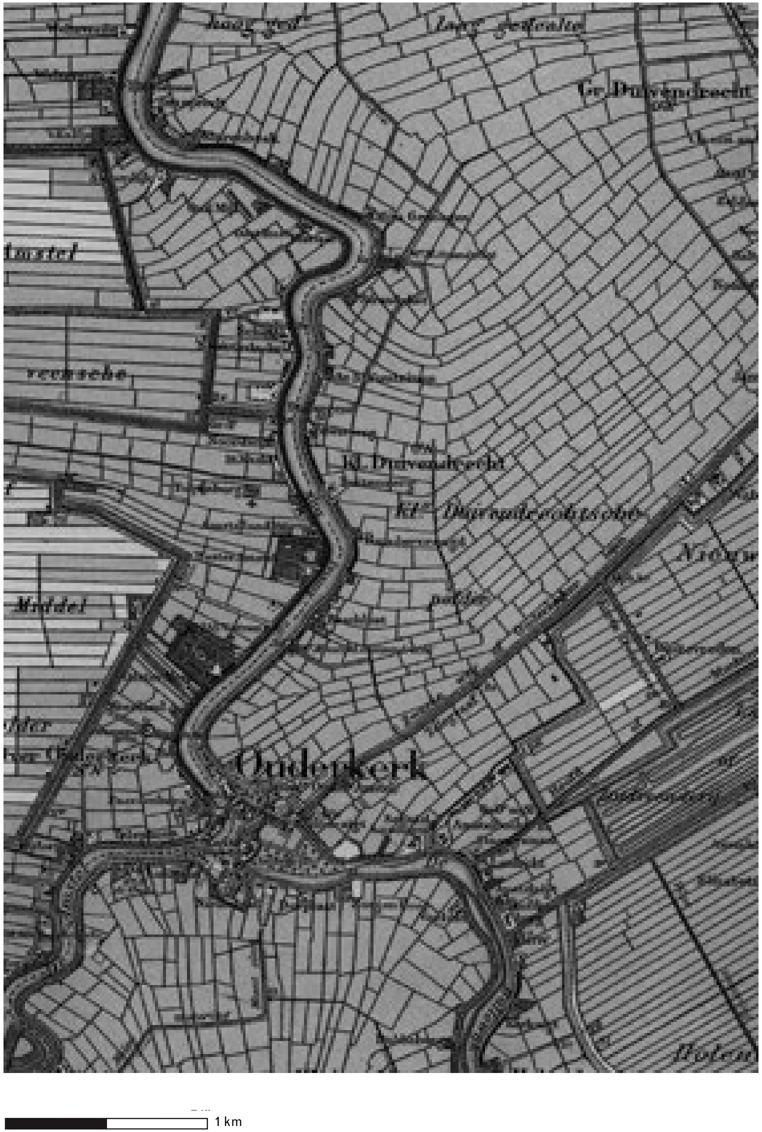
policy for the 21st century [18] is that room must be created for water, instead of depriving it of space. One of the measures introduced to achieve this is the Water Test. This measure is designed to integrate water-management considerations in spatial planning and decrees.[19] Shared obligation is a new aspect in this: joint involvement of initiators and water managers from an early stage. In this way, water-management issues (e.g. safety, flooding, water quality, salinisation and dehydration) can be resolved through a coherent joint approach.

This measure proved necessary because, in the 20th century, valuable knowledge was lost regarding the relationship between man-made landscape and cities. From the 1960s onwards, the pace of urban expansion increased exponentially, as did building output until 2008. In the construction sector there was little attention for the *genius loci*, i.e. the specific character and characteristics of a place, and as a result the water system was systematically – and, where necessary, unsparingly – altered. As a result of the transformation brought about by human intervention, the underlying landscape has lost visibility and identity.

In order to make polders suitable for building on, several metres of sand were deposited on them to improve the soil strength. The lines of water in the man-made landscape were hidden underground in the form of mains. In the cities that already existed, water was also removed from view. The ubiquity of water in the Dutch cities and landscape is now only evident in street names such as Goudsesingel (*singel* = canal) and the Binnenrotte (referring to the River Rotte) in Rotterdam. Here the open water was filled in and canals and peat rivers were diverted underground to make space for traffic. Many towns and cities in the Dutch Lowlands lost their relationship with the underlying landscape through the construction of streets and growing building density. This is almost incomprehensible if one considers that water was the reason for establishing the settlements, which grew into the Dutch polder cities. The first settlements in the peat bogs were situated where peat rivers flowed into rivers. These settlements flourished thanks to transport over the waterways, which made trade possible.

Interventions in the polder landscape

The changes in the polder landscape are clearly visible on the map sections showing Amsterdam-Zuidoost, with many peat polders along the Amstel and, in the west next to the motorway, the urban expansions. The landscape has changed radically in the past fifty years, mainly due to urban growth. On the east side of the map we can distinguish the typically dense network of ditches in the peat polders. On the water map (right) we can see that modifications have been made through the construction of weirs, culverts and pumping stations, but the pattern of the watercourses has not changed. The spatial appearance has not changed either, since the waterworks are relatively obscured. Farmers installed the elements so that the water levels could be manipulated in order to make optimum use


Amstel
veensche
Middel
Gr. Duivendrecht
Kl. Duivendrecht
Ouderkerk
1 km


1 km

◂◂
Section of a map showing Amsterdam- South-East in 1888, alongside a recent map in which all the technical elements that regulate water management in the polder are indicated. In the urban area the polder water structure has become invisible.

of the land. However, the construction of two motorways radically altered the structure of the polder and the ditches were cut off everywhere. In the built-up area nothing is left of the former network of ditches; the water has been channelled underground, out of sight.

The task

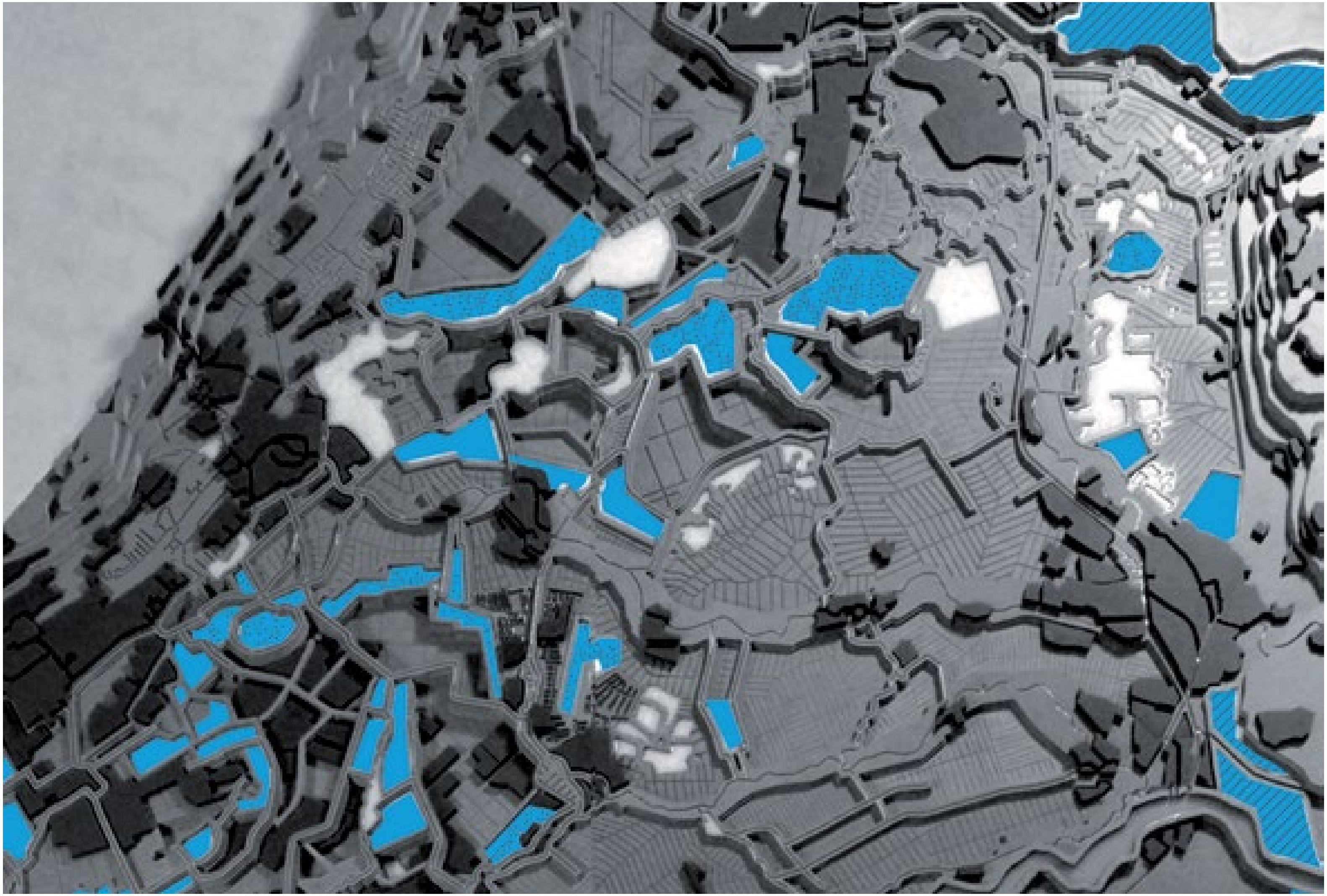
A distinction is made between the main water system and the regional water system. The problems relating to the main water system, such as the rising sea level and higher river levels with extra peak flows has produced integrated, inventive and spatially promising solutions. With regard to the regional water system, the situation is very different. It is a little less urgent and solving problems in this context is mainly the responsibility of the municipal and provincial authorities, who are not able to approach them in an equally integrated way. Ultimately, however, in addition to new approaches to water, cooperation is also essential at this level, especially between administrators, contracting parties, Regional Water Authorities and designers.

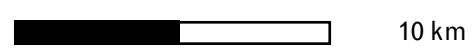
By now, everyone who works with water is aware that the approach involving the three-stage strategy for dealing with flooding (i.e. collecting the water, storing it in the polder itself, and only discharging it as a last resort) is the most sustainable approach.[20] At the design stage, each location should still be considered individually.[21]

Collecting means that rainwater is held in the ground, whereby the groundwater level fluctuates within an agreed range. Storing the water means that water is stored in watercourses, surface water or on the ground level; the level of this water is allowed to fluctuate within agreed limits. Water discharge by means of weirs, sluices and pumping stations will always be necessary in the Dutch Lowlands, due to excessive precipitation and the low elevation of the land in relation to the open water.

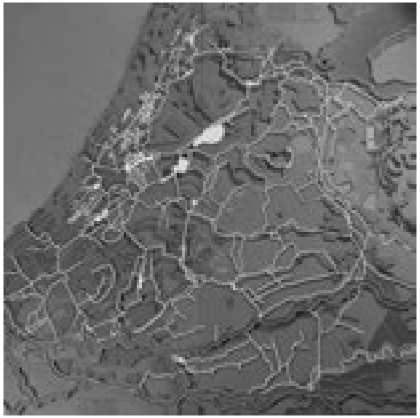
More pumps to discharge rainwater and let in water from elsewhere during dry periods are modifications within the existing system, which provide only a temporary solution. Making ‘space for water’, so that supply storage and peak storage can take place within the system, means changing the system, and that would have a considerable impact in spatial terms. The demand for more and cleaner water is increasing as farming methods become more and more intensive. Consequently, salty and polluted seepage is an ever-growing problem. Extending the practice of flushing out the affected polders out using freshwater is a much-used method, but this is not a sustainable solution.

20 Commissie Waterbeheer in de 21e eeuw (WB21, 2000) in its advisory report
21 http://www.citg.tudelft.nl/live




10 km

Peak-flow storage
Supply storage
Preventive storage (salinisation)
Existing water



◀
Map showing the water management challenge. For the 2nd Architecture Biennale in Rotterdam in 2005, Landscape Architects H+N+S built a scale model to illustrate the water management challenge, a large share of which consists of water storage. In this model they showed the different sorts of water storage and indicated the specific locations.
The small map at the top of the page shows the existing situation.

The water question visualised

On the basis of current knowledge regarding climate change, H+N+S Landscape Architects calculated that the area required for water-storage capacity in the Randstad conurbation would be 20,000 hectares, to ensure people can live in the area safely.[22] The bureau identifies three types of water storage: supply storage, seasonal storage and peak-flow storage.

In the case of supply storage water can be held in the area and linked to seasonal storage. Seasonal storage areas make an important contribution to water quality. The water level fluctuates, and water can be let into the polder from the storage area during dry periods. In the model also storage areas have been indicated, which combat salty seepage in the lower-lying polders through counter pressure.[23] Obviously, these bodies of water could also be used for supply storage and, to a certain extent, be combined with seasonal storage.

As a result of the increase of hard surfacing in urban areas, water enters the *boezem* system directly and rapidly. Apart from the *boezem*, there is little space to store water in the towns and cities in particular. The existing *boezem* must therefore be able to hold increasing volumes of water during periods of heavy rainfall. In case of danger emergency polders are pointed out as outlet of the *boezem* system. The water flows via the *boezem* or even the primary water system (e.g. a river) into the emergency polder. The water remains in the emergency polder, and flows from there into the sea several hours or days later when the water level has fallen. In normal whether circumstances they are used as agricultural land. Peak-flow storage areas are storage areas with the capacity to hold very large volumes of rain that fall in a short period (peak). Various areas spread across the map have been designated as temporary water storage areas.

In the model, for practical reasons, whole polders of several meters deep are set under water up to the crown of the dike. The photograph of the model illustrates the enormous water-storage capacity required and indicates appropriate locations in the Randstad conurbation. This is a perfect illustration of the quantitative challenge posed by water-related issues.

An analysis for the 'water pilot' project for Amsterdam-Zuidoost commissioned by the municipal authority is based on the principle that the volume of water that has to be stored in the Dutch Lowlands is equal to a layer of approximately 180 mm of water spread out across the whole area.[24] This theoretical figure was obtained by calculating mean precipitation figures of 800 mm/year minus the accompanying mean evaporation rate of 150 mm/year, the amount of water that penetrates the soil, is taken up by plants and evaporates again, and the volume of water that drains into the groundwater.[25]

Due to seasonal variations, there is an excess of water in the polder during the autumn and winter, and a shortage in the spring and summer. A water-storage level of 180 mm would mean that water would not need to be let in from another area. Because large parts of the polder are developed, and wet polders are unsuitable for agricultural

22 Bureau H+N+S. (2005). *Pleidooi voor waterrijk handelen*, 2e editie. Architectuur Biënnale Rotterdam
23 Aquade voorstellen, bureau H+N+S
24 Bobbink, I., Kooij, E. van der (2009). 'Ontwerpen met water in Amsterdam Zuidoost.' *Rooilijn*, pp. 58-65
25 Lijn43. (2010). *De Bosatlas van Nederland waterland.* Noordhoff

purposes, it is necessary to store more water in some places so that less storage is necessary in others. Specifying an overall volume of water, and assessing the need and possibilities for storing water on a location-specific basis can make this into a particularly challenging exercise. The contour of the polder is the stage for the design, but not necessarily the fixed framework.

◀
Water can be used in many ways to shape the (urban) landscape; the fortified town of Naarden is a good example of this.

The *legakkers* (island to dry the excavated peat) are used to locate summerhouses.

The Naardermeer, today a nature reserve, is the result of a struggle between man wanting to dry the lake (to polder it) and nature which took over in the end.

The Voor- and Achterplas on the north edge of the city of Rotterdam are residues of the peat digging. Today the area is used for recreation and exclusive living.

Peatland lakes are characterised by bodies of water containing long, narrow strips of land. These strips were initially used for drying the excavated peat, and later for housing and recreation.

Conclusion

As a result of climate change we are faced with the necessity of restructuring the water system based on an integrated approach. It seems that the current approach – namely that of using pumping stations to manage polder water, raising the height of dikes along the rivers and endless coastal replenishment – will no longer provide a satisfactory solution in the long term. More space needs to be given to the water, which obviously is an enormous challenge in our densely populated Delta. Land prices and processing costs are rising and it becomes more and more difficult to make a profit in agriculture. Farmers are relocating to larger expanses of land, and as a result we need to think about new management and/or new programmes for parts of the cultivated landscape.

Because water has a spatial claim, this provides an opportunity for water design. So the task should be seen not just in terms of water management, but as an integrated spatial challenge. Water is no longer only the domain of the water managers; it has become part of spatial planning on the scale of the Netherlands within the European context.

Since the conclusion, in 2003, of the National Water Management Agreement (*Nationaal Bestuursakkoord Water,* NBW), in which the four levels of government (state, province, municipality and Regional Water Authority) agree to work together, the scale and qualities of the water are gradually starting to be utilised again for rural land-use planning. As at the beginning of human occupation of Holland, water can again play a determining role in the landscape-architectonic organisation of the present-day, heterogeneous urban landscape of the Delta. In this context, it is essential to adopt an interdisciplinary approach based on spatial research (design-driven research), in cooperation with civil engineers, geophysicists, hydrologists, ecologists, urban designers, architects and landscape architects.

There is a great deal to be learned from the existing water landscapes and their polder-*boezem* system. The centuries-old diversity of water patterns, structures, techniques and forms is impressive. From a landscape-architectonic perspective it is interesting to ask ourselves how and where in the system the water that is present, including the stored water, can become meaningful in a spatial sense. For example, how visible are the pumps and sluices that are vital for keeping the land dry? What is their role in the spatial composition of the polder water? How can larger bodies of water be incorporated in an existing polder? Which specific design features and strategies can be found in the various existing water landscapes? How could these be renewed?

In order to answer these questions, we can draw on centuries of knowledge of the polder landscape itself. The next chapter will focus very specifically on polders, in order to make this knowledge visible and activate it in the landscape-architectonic context.

The development of the polder landscape

Around the beginning of the A.D. era large parts of Holland consisted of peat bogs, which slowly built up through the cycle of plant growth and death to form areas of wetland a few metres high, the natural landscape in this area. Water drainage over many centuries led to the formation of peat polders, peat extraction led to peat lakes, and drainage of these lakes created the lake-bed polders.

The natural landscape

From about 2200 B.C., sand ridges formed along the coast; these prevented the sea from penetrating further inland. A period of extensive peat formation began that continued into the A.D. era, resulting in the Hollandveen peat layer. Rich bog vegetation grew along the rivers and peat streams, the remains of which turned into peat. Away from the influence of the nutrient-rich river water, moss peat could develop, consisting of mounds of peat some 15-metres thick, formed from accumulations of dead plant material. Excess water drained away via the peat rivers. Today there are still a number of waterways (the Rotte, the Waver etc.) in the west of the Netherlands that started out as small streams through the peat bogs.

In many places, the soft soil material was eroded by the wind, and large lakes formed in the natural landscape.[1]

The cultivated landscape around the 8th century

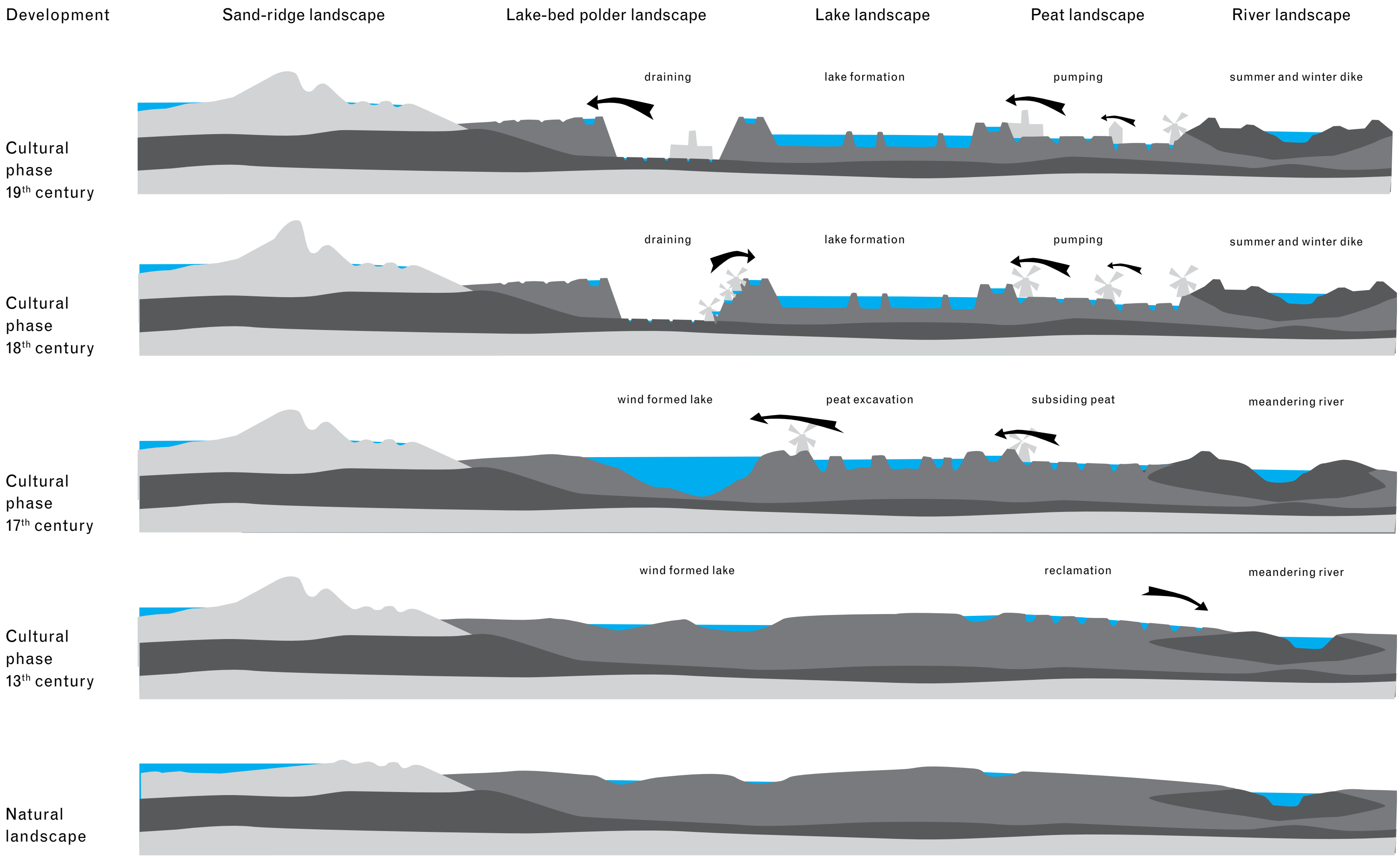
The peat-polder landscape is a result of the reclamation of peat bogs. As early as the 8th century, people were draining the peatlands by digging parallel ditches perpendicular to peat rivers, in order to make them fit for habitation and farming. A river, excavated watercourse (*wetering*), road or dike served as reclamation 'base'. In the beginning, the peatlands drained naturally. The ditches were connected to the peat river or *wetering* by means of check valve sluices (*klepduikers*). The geographic location and the position of the excavated land in relation to the drainage courses certainly played a role in determining the direction of the ditches. In order to prevent flooding from the peatlands that had not yet been excavated, peat embankments or peat dikes were built. The direction of discharge and the line of demarcation were set out in advance.[2]

The reclaimed land was initially used for growing crops, but due to settlement (subsidence of the land) it could only be used as meadowland at a later stage. The land continued to subside, and the excess water could only be discharged to the *boezem* through a discharge sluice. The *boezem* remained at the same level in the landscape, and the surrounding land sank. The sides of the *boezem* dike had to be constantly reinforced. Due to this fact, and to the instability of the peat-bog material, peat dikes have a gentle slope. Along the main rivers, more and more dikes were built to prevent flooding. The inhabitants built dams at the points where the peat rivers flowed into the big rivers, and controlled the flow of water into the river by means of an outlet sluice. Many towns and cities owe their existence and growth to this hydraulic-engineering intervention: Amsterdam, Rotterdam, Alblasserdam, Schiedam, Edam, etc.[3]

1 Bobbink, I. (2009). *Land inSight, a landscape architectonic investigation of locus.* SUN

2 Hoep, F.S. (2000). *Holland Kompas, 2000 jaar watergeschiedenis.* Uitgeverij bureau Hoep & Partners

3 The sources of the water terminology are as follows: http://www.encyclo.nl/begrip http://www.xs4all.nl/~davdree/NL/glossarium.htm Voorde, M. ten (2004). Final-year research report. University of Twente Danner, H.S., Rijswijk, B. van, et al. (2009). Polderlands, Glossarium van waterstaatstermen. Stichting Uitgeverij Noord-Holland, Wormerveer



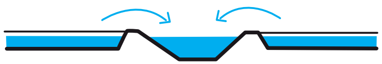
The cross sections describe the transformation process of the Dutch landscape in five phases. The natural landscape of the lowland polders would have looked much like the landscape in the previous photo.

In each of the landscapes described here, water and water levels play an important role. If natural forces of gravity no longer drain a landscape and man intervenes we refer to it as a polder landscape.

Peat ditch

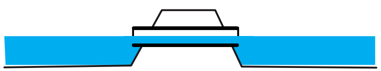
Dozens of parallel, man-made, slightly meandering lines of water carry away seepage and rainwater from the soil. The banks of the ditches are under constant threat from water erosion, therefore the edges of the land are irregular.

Wetering



A *wetering* is an excavated watercourse, usually straight but sometimes meandering. During the reclamation of the low peat marsh, digging a *wetering* was particularly important for drainage. A *wetering* was dug parallel to the reclamation base (e.g. a road, dike or levee) and at right angles to the ditches. The peatland between the base and the first *wetering* was reclaimed, and the process was then repeated.

Check valve sluice (*klepduiker*)

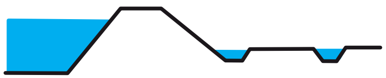


Mechanism for draining excess water. On the discharge side of the sluice there is a valve that is opened by the pressure of the outflowing water, and closes to prevent water flowing in. Examples of such sluices have been found dating from 1200, made from a hollow tree trunk placed across the dike.

Embankment

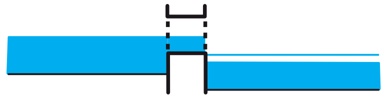
A low water water-retaining construction in peat grassland areas that is of a lighter construction than a dike. The purpose of a back dike – a low embankment behind the plots of land or *slagen* – was to protect the reclaimed land from the water in the peatland, which was on a higher level. An embankment can also be an area of residual peatland that has remained due to peat excavation and the resulting soil settlement in adjacent land.

Dike



A water-retaining construction – usually raised earth, sometimes covered with stones or asphalt – whose height and width depends on its function. Its purpose is to protect the land behind it from flooding. The slope of the outside of the dike (the exterior slope) may differ from that of the inside of the dike (the interior slope). At the foot of the dike there is usually a ditch that can hold the seepage caused by a higher water level on the other side of the dike.

Discharge sluice



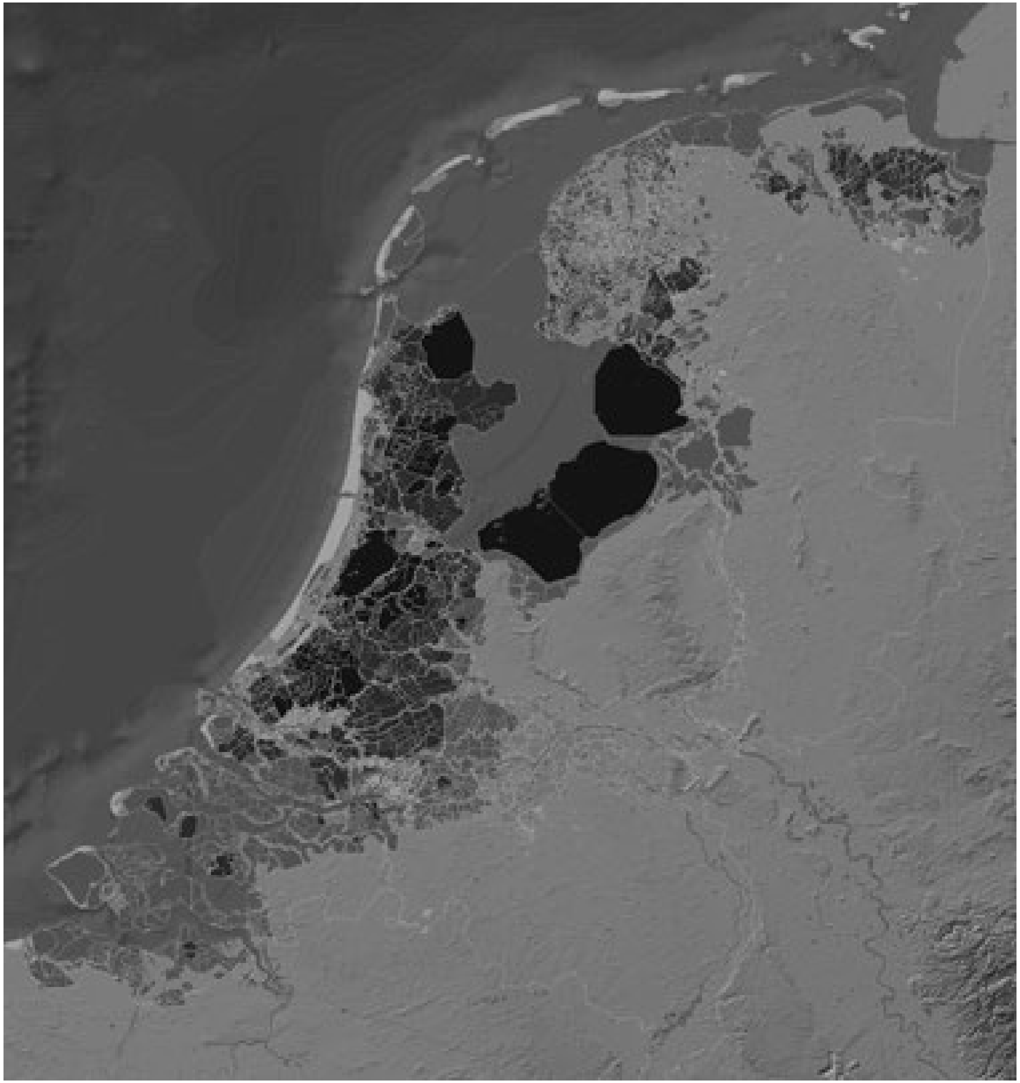
This is a sluice through which excess water can be discharged into an area where the water level is lower. When the level of the water outside is low, the water flows out of the polder via the sluice. At high tide, when the level of the water outside is higher than that on the other side of the sluice, the pressure of the water closes the sluice.

Dam

A water-retaining structure that is built across a watercourse in order to separate two bodies of water. Many settlements that later evolved into towns and cities were established near a dam in a peat river close to a big river.

Weir

A structure that holds back water so that various water levels can be maintained in a watercourse. There are fixed weirs, sometimes consisting only of a wooden plank, and variable weirs that can be set for different water levels.



The Polder map shows the respective depths of the polders. In the case of the lake-bed polders (dark) you can see that the younger they are, the larger they are. This increase in scale has to do with the increased capacity of modern pumping stations.

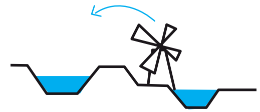
The cultivated landscape around the 15th century

From the 15th century onwards, mills were necessary to drain the land and maintain the required water level. The mills discharged the water from the lower-lying land into the *boezem*. The reclaimed landscape became a polder-*boezem* system. A polder is drained by pumps in order to maintain the required water level in the polder or the adjoining *boezem*. Due to the rapid development in mill techniques, and the benefits for agriculture of draining the land, mills rose up everywhere in the landscape. The open landscape was changed into a picturesque landscape, with dozen of mills visible on the horizon. Constant drainage also caused the peat-settlement process to accelerate rapidly.

The ground level sank, not only due to drainage but also to peat excavation. Dried peat was used as fuel and transported to the towns and cities along the waterways. Whole areas were excavated, initially above groundwater level. Later, from the second half of the 15th century, the invention of the hand drag made it possible to excavate peat below the groundwater level. Large peatland lakes developed in the landscape.[4]

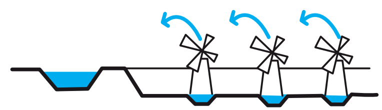
4 The sources of the water terminology are as follows: http://www.encyclo.nl/begrip http://www.xs4all.nl/~davdree/NL/glossarium.htm Voorde, M. ten (2004). Final-year research report. University of Twente Danner, H.S., Rijswijk, B. van, et al. (2009). Polderlands, Glossarium van waterstaatstermen. Stichting Uitgeverij Noord-Holland, Wormerveer

Polder mill



The first wooden polder mills were developed from the beginning of the 15th century. The blades caught the wind, which powered a scoop wheel that could lift the water some 1.5 metres. The water could be lifted considerably higher than this if a screw pump was used. Mills with a scoop wheel or screw pump are part of the cultural-historical heritage of the Netherlands. Thousands of mills have disappeared from the landscape over the years, and have been replaced by modern pumping stations with a much greater pumping capacity.

Parallel discharge



A row of polder mills pumping water simultaneously from the same polder level to the same outlet, or directly into the *boezem*. This set-up enables large volumes of water to be pumped out at the same time. Due to technical advances, it was possible to replace the rows of windmills with a single pumping station of the same capacity.


Peat river (*boezem*)
Main canal
Uplands
Uplands
Lake landscape
Lake-bed polder
Lake-bed polder
Peat landscape
Lake-bed polder

The cultivated landscape around the 17th century

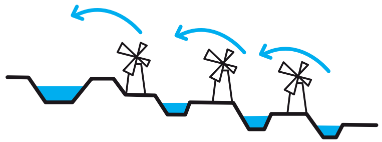
In the 17th century, further advances were made in drainage techniques, ideas evolved with regard to draining natural lakes that had developed due to wind erosion in poorly maintained watercourses, or artificial lakes created through excavation of the peat layer. The lake bed was composed of clay and offered attractive investment opportunities for creating new fertile land for farming. Dikes were built around the body of water using material that was dug from the site. Where this material was dug out, a ring canal was created that would drain away the water from the lake, and later from the polder. The creation of a lake-bed polder combined efficiency with insights taken from science and art. The plans for these polders evolved on the drawing board and through experiments in situ.

In some cases, the water had to be lifted up several metres in order to drain a lake. In such cases the mills were set up in a multi-stage configuration. Some lake-bed polders had more than four of these configurations, with a set of mills active on each level. Once the natural or artificial lake had been drained, some of the mills were dismantled and used for other projects. Drainage ditches were then excavated in the new land to carry the water to the pumping point via the previously excavated main channel, usually situated in the middle, along the length and/or the transverse axis of the polder.[5]

Ring canal

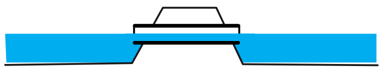
A ring canal (*ringvaart*) is a canal around a polder, outside the ring dike. The canal is excavated when the polder is being drained, and its permanent function is to collect and carry away excess water that has been pumped out of the polder. The ring canal is part of the *boezem*.

Multistage mills



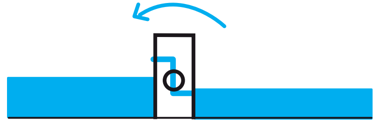
A line of three or four polder mills that pump water in stages from a deep polder (lake-bed polder). Each mill in the series pumps the water into an elongated water basin on the next level, no more than 1.5 metres higher. The water is eventually discharged into the *boezem*.

Culvert



A cylindrical water connection under a road or dike. Culverts are installed in the ground and are not usually visible. Sometimes the ends are visible, and form part of a design.

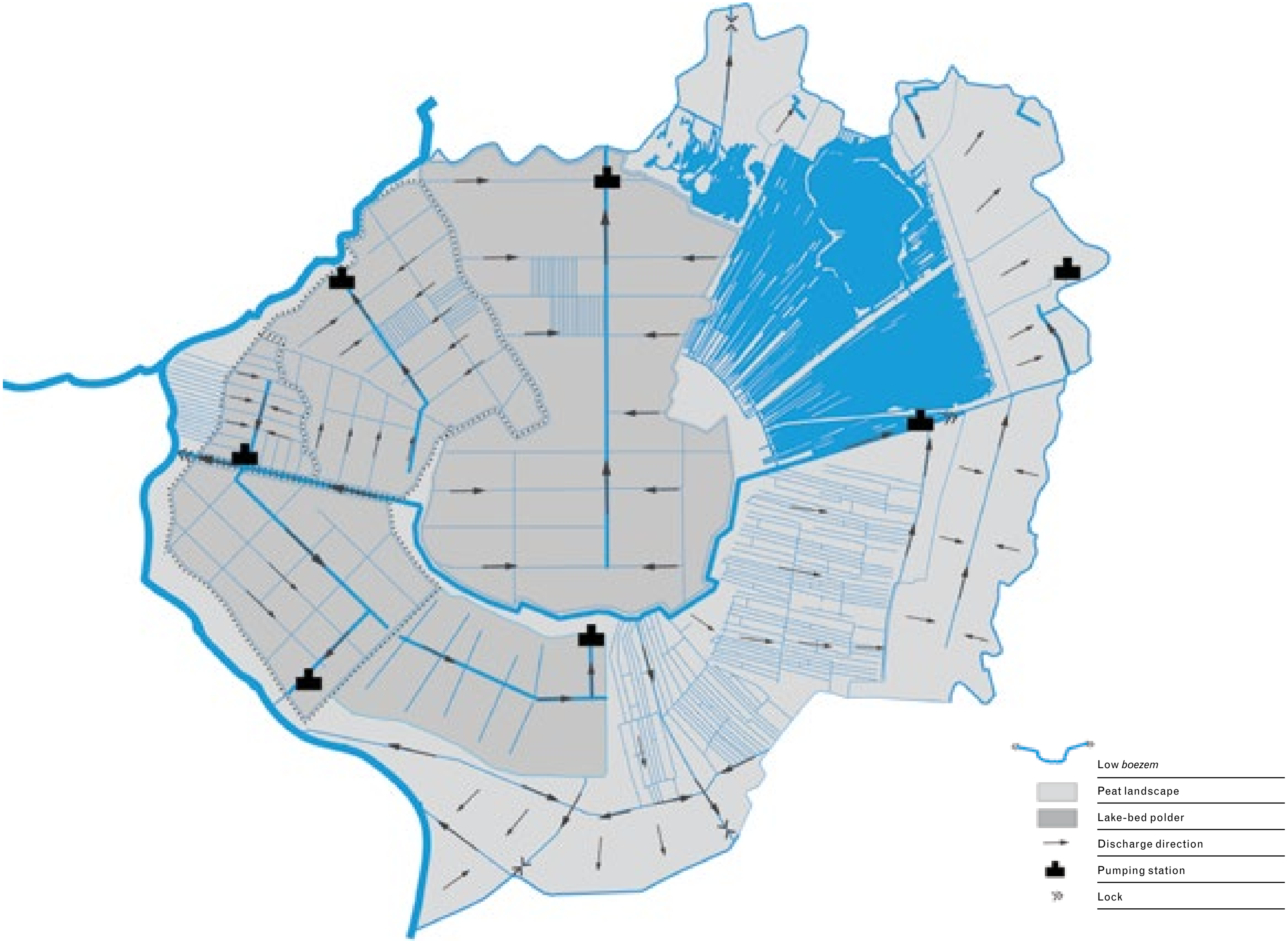
Lower-level pump (*ondergemaal*)



A small pumping station installed in the middle of the polder in order to drain part of the polder, either because the ground level in that part of the polder is lower, or because a lower groundwater level is required (e.g. arable farming requires a lower groundwater level than grassland). These pumping stations – a small mill or electric pump – are installed by the farmers.

In this book the Ronde Venen polder complex will frequently be used as an example. In this complex various types of polders can be found in close proximity. You can still recognise the original peat-mound form of the polder complex in the plan.

5 The sources of the water terminology are as follows: http://www.encyclo.nl/begrip http://www.xs4all.nl/~davdree/NL/glossarium.htm Voorde, M. ten (2004). afstudeerverslag. Universiteit Twente Danner, H.S., Rijswijk, B. van, et al. (2009). *Polderlands, Glossarium van waterstaatstermen.* Stichting Uitgeverij Noord-Holland


Low *boezem*
Peat landscape
Lake-bed polder
Discharge direction
Pumping station
Lock

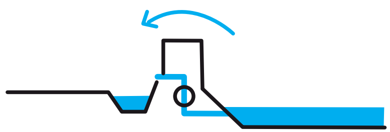
The cultivated landscape from the 18th century onwards

The invention of the steam engine meant that mills could be replaced by steam pumping stations with a much larger capacity. It became possible to drain ever larger expanses of water, such as the Haarlemmermeer (the 'water wolf'), which threatened the city of Amsterdam. In the 1930s, diesel-powered pumping stations were introduced. Thanks to this new technology, more water could be pumped out more quickly, which accelerated the soil-settlement process. Mills gradually disappeared from the landscape.[6] New driving-gear and elevating technology made it possible to drain polders that were 6 metres below the Amsterdam Ordnance Datum. Today, Archimedes' screws, vertical screw pumps or centrifugal pumps are used to raise water from a lower to a higher level. The drive mechanisms are usually electric. However, mainly thanks to the work of the 'Gemalenstichting', a foundation focusing on the preservation and maintenance of older types, working pumps powered by diesel, steam or wind still survive.[7]

Today, water levels in lake-bed polders and peat polders are usually regulated by means of electric pumps. As the capacity of the driving gear increased and the installations themselves became smaller, they have become less and less visible in the landscape. The number of pumping stations has fallen sharply in recent years, and many of them are too small and too well concealed to be recognised by someone without specialist knowledge. Another common phenomenon is the construction of as many as two generations of new installations next to an obsolete one. In these kinds of arrangements that have evolved over time and were not planned as such from the outset, it is no longer possible to define the relationship to the water structure and *boezem*. The most notable element of modern-day pumping stations is filtration, which prevents larger elements floating in or on the water from entering the pump. Because the grilles can be activated automatically and at any time, the entire station is fenced in.[8]

6 http://www.molens.nl – De Molen Stichting
7 Rijn, C.D. van (2007). DE NGS Gemalen Gids. De Nederlandse Gemalen Stichting
8 The sources of the water terminology are as follows: http://www.encyclo.nl/begrip http://www.xs4all.nl/~davdree/NL/glossarium.htm Voorde, M. ten (2004). afstudeerverslag. Universiteit Twente Danner, H.S., Rijswijk, B. van, et al. (2009). Polderlands, Glossarium van waterstaatstermen. Stichting Uitgeverij Noord-Holland

Polder pumping station

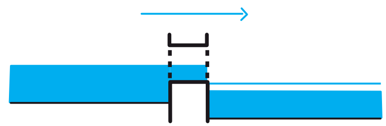


Installation that pumps water from a lower level – the polder – to a higher level – the interlinking *boezem*, the *boezem* or directly into the water outside the *boezem*. This ensures that the required water level is maintained in a water-level area. Pumping stations usually drain water from the polder, but there are also stations that bring water into the polder.

Navigable lock

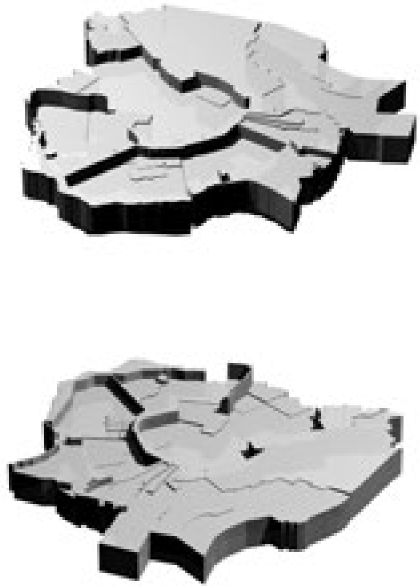
A lock equipped with double gates to allow shipping to navigate waterways on different levels. A navigable lock consists of an upper gate that connects to the higher level, and a lower gate that connects to the waterway on the lower level. The area between the two lock gates is known as the lock chamber.

Inlet



An inlet is an element with which the flow of water into the polder can be regulated. This enables water levels to be maintained, or the water to be set in motion, which is beneficial for its quality. The inlet may be open and visible and, where there are large differences in elevation, have a stepped structure. Usually, however, inlets are not visible, and consist of a culvert in the water-retaining structure, and a gate or valve at the higher level that can be opened to let in water.

Analysis drawings of the reclamation process in the polder complex the Ronde Venen
Peat Extraction: peat polders, lakes and lake-bed polders in the complex alongside each (1998 and present-day), which have evolved into each other over time.



The spatial analysis drawings show the various set water levels – summer/low and winter/high – in the various polders that the complex consists of.

The Ronde Venen polder complex

In the Ronde Venen, the size and shape of the former peat cushion can be clearly seen from the circular ground plan of the complex. The area forms part of low-lying peatlands to the west of Utrecht, and consists of peat polders, lake-bed polders and an artificial lake. These polder types, as here in the Ronde Venen, can exist alongside each other, or replace each other over time. [9]

The development of the Ronde Venen

From the 11th century onwards, people began to dig ditches in the bog areas in order to make them inhabitable. The ditches ran at right angles to the peat rivers, towards the top of the peat mound. Due to the length of the ditches and settlement of the peat, transverse ditches had to be dug for drainage. Mills were used to pump the water out of the peatland. From the 18th century onwards, peat excavation began in the Ronde Venen, resulting in the creation of large artificial lakes. People feared that it would not be possible to contain the growing bodies of water resulting from peat excavation, and by-laws stipulated that the lakes had to be drained. The approach to draining was a fairly pragmatic one. Plans were drawn for the first polders, but the most recent lake-bed polders follows the pattern of the peat polder. Along the peat rivers, the *boezem* of the Ronde Venen, there is peatland. The level of the water in the peat polder is more or less the same as that of the Vinkeveen lake, which evolved in the interwar period and now serves as a reservoir and recreation resort and whose level is that of an interlinking *boezem*. [10]

The transformation processes can be made visible using analysis drawings. The water pattern determines the spatial appearance of the polders. The appearance of the polder is determined by the interaction between its basic form and the way it is adapted to the situation and by the technical possibilities available at that moment. Next to that its form depended on the aesthetic ideals that prevailed when the polder was created, by its function and by societal and economic needs of the land.

The drawing based on maps from around 1696 shows that the boggy peat mound was already being extensively cultivated by farmers, who dug a wedge-shaped network of ditches between the peat rivers and the top of the peat layer - all under the watchful eye of the Chapter of Utrecht.[11]

The drawing based on maps from around 1850 shows various subsequent adaptations of the landscape. Apart from the development of artificial lakes resulting from peat extraction, the first attempts were being made in the west of the Ronde Venen to drain land for farming.

The drawing based on maps from around 1920 shows the process of earth removal and draining that was still under way a century later. The structure of the ditches has changed, and the network of ditches in the individual reclaimed polders is now block-shaped.

In the drawing based on maps from around 2000, the various polder treatments of the original bog landscape are situated alongside each other in the polder complex. The Ronde Venen is unique in this respect. The polder-*boezem* system is still being modified. The ‘makeable’ landscape requires constant maintenance. Today people are exploring the possibility of putting some parts of the land under water again rather than reclaiming more.

9 Bobbink, I., Rickert, N. (2008). *Van veenbult tot ingenieuze watermachine.* interne publicatie. TU Delft

10 Blijdenstijn, R. (2007). *Tastbare Tijd, cultuurhistorische atlas van de provincie Utrecht.* Uitgeverij provincie Utrecht

11 Wit, (2009). *Dutch Lowlands.* SUN

GIS is used to provide insight into the spatial consequences for ground use. The current number of water-level areas (*peilvakken*) in the area is considerable (top left); the drawing below shows the simplified water-level management (bottom left).

Reducing the number of water-level areas creates development opportunities for water storage and nature development, in addition to agricultural land (bottom right).

The water levels maintained in the lake-bed polders of the Ronde Venen are higher than those that would be necessary for arable farming. The land is used mainly as grassland. The water level varies with the seasons. In the winter it is higher, because less water evaporates. During a dry summer, so much water evaporates that it has to be replaced with water from the *boezem* system. The whole water system can be set in motion by switching the pumping stations on and off, or by having them turn in the opposite direction.

Peat polders that are higher than the lake-bed polders are a typical feature of the Dutch lowlands. The aim is to keep the water level in the peat polders as high as possible in order to minimise further settlement of the peat. The oxidation process in the peat takes place mainly in the summer, and can be slowed by maintaining a higher ground-water level. Water has to be let in for this purpose.

12 Woestenburg, M. (2009). *Waarheen met het Veen, kennis van keuzes in het westelijke veenweidegebied.* Uitgeverij Landwerk

13 Vista, Landschapsarchitectuur en Stedebouw. (2005). *Onderzoek: Functie volgt peil in het Groene hart.* Staatsbosbeheer

The peat layer in the Ronde Venen is several metres thick, which means that the subsidence could continue for many years. The rate of subsidence is determined by the ditch water levels in the peat grassland areas and by the soil profile.

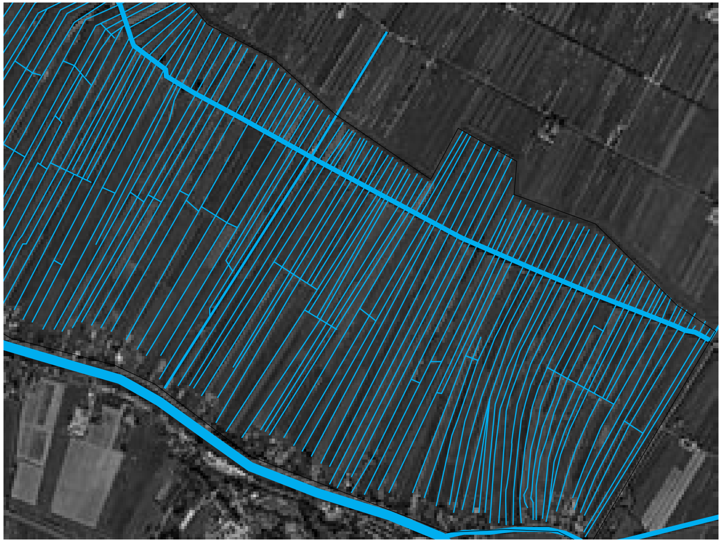
In July 2009 the Dutch cabinet decided to invest 113 million euros in the peatland areas in the west of the country in order to slow the subsidence and make the water system more robust.[12]

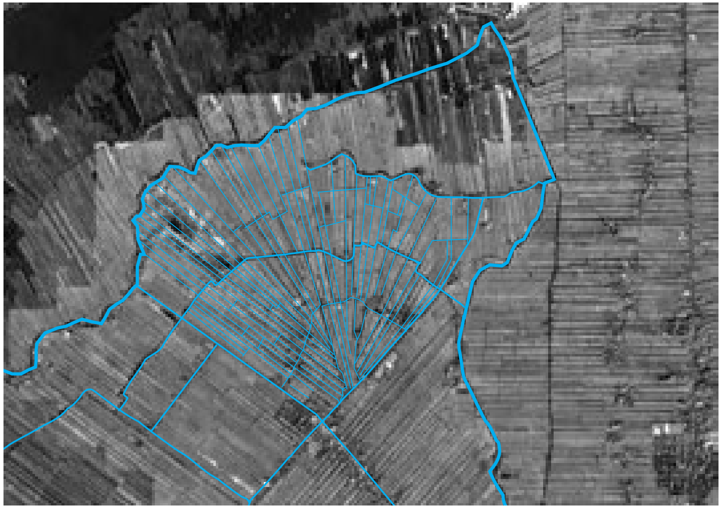
The 'function dictates level' study

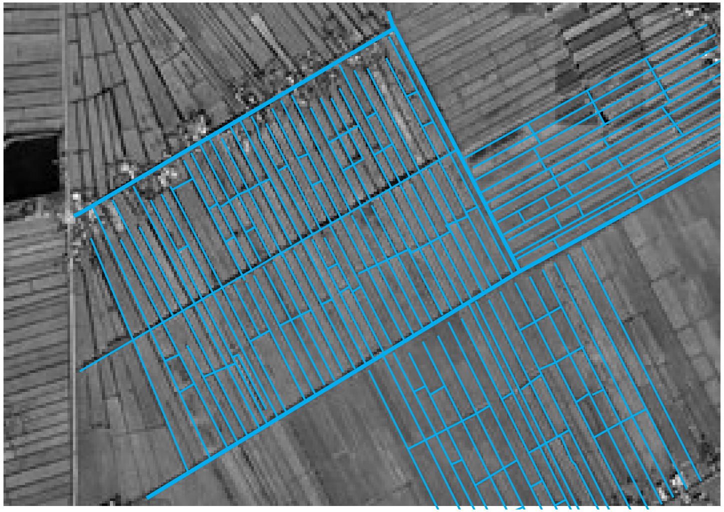
In a study commissioned by Staatsbosbeheer, the research and design firm Vista researched the influence of simplified water-level management in the peat regions.[13] As a result of the 'function dictates level' approach, the water system became increasingly fragmented over the years. In order to combat this effect, larger designated water-level areas with adapted land use were introduced. The aim was to allow a higher water level in lower-lying areas and maintain a lower water level in the higher sand and clay soils, in order to combat subsidence in the peatlands and make water management more organised and cost-effective. The introduction of larger designated water-level areas with an average water level slowed the subsidence in the lower-lying peatlands, and the development of wetland habitats created space for water storage and nature development. On the higher sand and clay soils, agriculture can continue to develop, and housing development is possible. The conclusion of the study is that the size of the designated water-level area and the specified water level are determining factors for the overall appearance and character of the landscape. Agriculture is literally losing ground. Additional measures and instruments are needed for the high peat regions in order to halt subsidence.

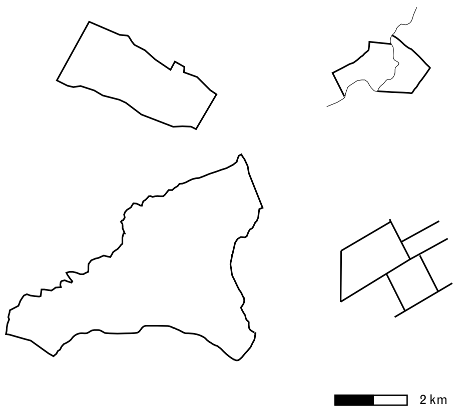
Drainage patterns

Drainage patterns are determined by the way a polder originally came into being. The main difference between drainage patterns in peat polders and lake-bed polders is that peat polders were created over time through the excavation of ditches, which at a certain stage had to be made to converge, becoming part of a polder system, while lake-bed polders were designed on the drawing board and excavated in their entirety, at one particular point in time. Both types of polder have distinctive patterns. But there are also polders that, as a result of their atypical soil bed, location or the circumstances in which they were excavated, are not so easy to classify. For example, there are peat polders whose reclamation was planned on the basis of a reclamation agreement ('*cope*' reclamation), and there are lake-bed polders that simply followed the pattern of past peat excavation.









Contour peat polders

◀

Province of South-Holland: fragment Noordeinderpolder along the Old Rijn - 'free' or strip parcelization

Province of South-Holland: fragment polder Lagebroek – fan parcelization

Province of Utrecht: fragment Aetsveldsche polder along het Gein – feather parcelization

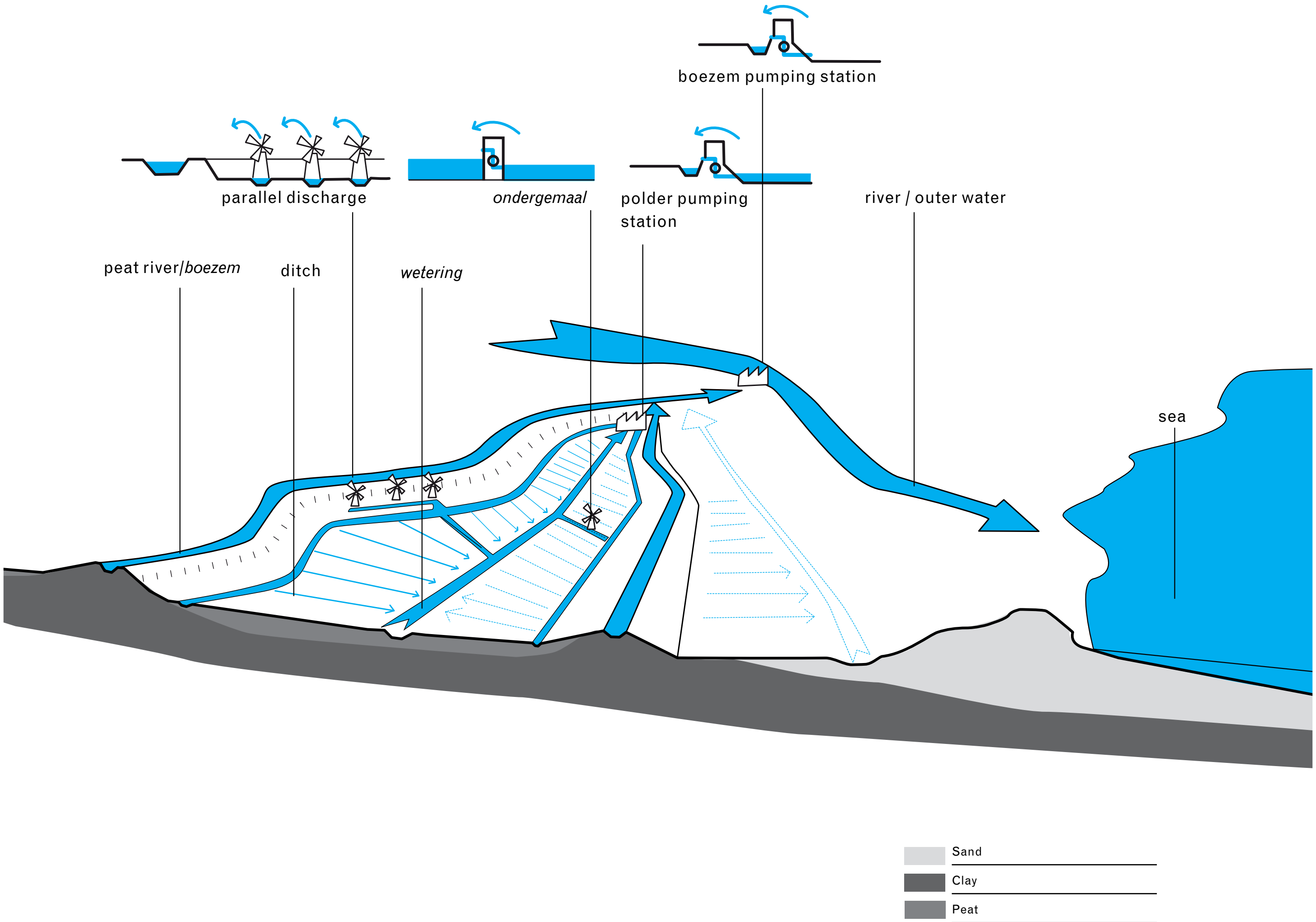
Province of Utrecht: fragment polder Teckop – *cope* parcelization

Drainage patterns in peat polders

Many different people reclaimed peat areas, over long periods of time. The soil conditions, the reclamation base and the designated parcel size determined the pattern. The reclamation base was the starting point for the excavation of ditches, which were dug at right angles to it. If the reclamation base was not a straight line, the pattern was one of diverging or converging ditches. The ditches could be freely extended until they either met an obstacle (e.g. another reclamation area) or converged, or met in a point. In cases of collective reclamation, the length of the parcels was agreed in advance. Large areas were systematically divided into blocks and ditches were dug to a regular pattern. The initial stages of constructing the reclamation pattern did not yet result in a polder. But due to subsidence, the ditches could no longer drain directly into the natural reclamation base, which had a different soil base and did not subside. To avoid having to build a mill in every ditch, a drainage channel (*wetering*) was dug. Depending on the size of the polder, the water was pumped from this channel into the *boezem* from one or more points. The drainage channels are on the same level as the ditches; they run at right angles to them and are wider.

The pattern of the peat polders outside the cities has not changed much in the course of a millenium. Peat polders consist mainly of plots that are longer than they are wide. Over the centuries, more and more small waterworks were introduced, such as weirs, small dams and lower-level pumps (*ondergemalen*). On the other hand, the number of pumps fell due to increases in pumping capacity. In terms of appearance, the land has changed from a cultivated landscape dotted with mills into a larger, emptier, open polder landscape. There are fewer pumping stations, and they are also less visible. In the current situation, the open picture of the landscape has become increasingly fragmented due to the ever-expanding built environment.

The following drainage patterns can be distinguished in a peat polder: 'free' or strip parcelization, feather parcelization, fan parcelization, *cope* parcelization, river-polder parcelization and residual parcelization. Polders along a river have a characteristic elongated shape: river-polder parcelization. This form developed because the ditches were dug at right angles to the river, which functioned as the reclamation base. When the land began to subside, the discharge direction of the ditches had to be reversed inland, towards the watercourses that had been dug parallel to the river. River-polder parcelization is still very evident in the river region. All other forms of parcelization in the peat polder are 'residual', draining the areas left between the main reclamations due to the variations in topography. These areas of land can be situated in a polder, or form a separate polder.


boezem pumping station
parallel discharge
ondergemaal
polder pumping station
river / outer water
peat river/boezem
ditch
wetering
sea
Sand
Clay
Peat

14 Stroeken, F., Wit, J. de, Brink, M. (2009). *Royal Haskoning rapport, Waarheen met het veen?* Stichting leven met water

Functioning and visual features of peat polders

Drainage in peat polders takes place in several steps, which together comprise the 'water sequence'. Each step in the sequence has its own characteristic form and materialisation, combined with typical built elements: the waterworks.

The water sequence in a peat polder consists of ditches and watercourses that discharge water into the *boezem* via a pumping station. The level of peat polders is usually about 2.5 metres below the Amsterdam Ordnance Datum. The drainage process is clearly visible due to the high water level. Where the land is wetter, the ditches are closer together and/or wider. The network of ditches forms the circulatory system of the landscape. The long ditches convey the scale of the open landscape and give a sense of direction. Particularly when one moves at right angles or diagonally to the ditch pattern, one experiences a strong perspective effect in the water landscape. The wider watercourses that run at right angles to the ditches reinforce the water-abundant appearance of the polder.

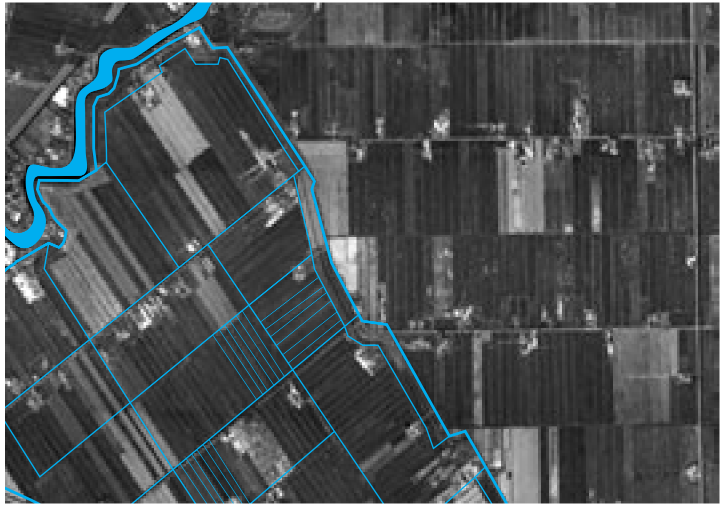
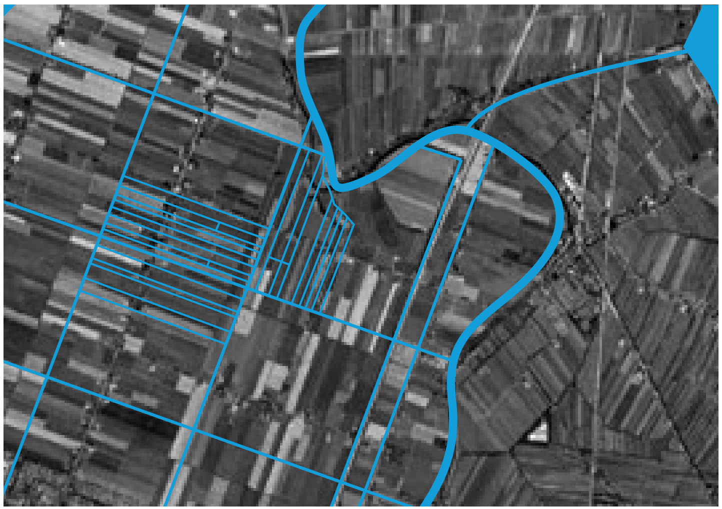
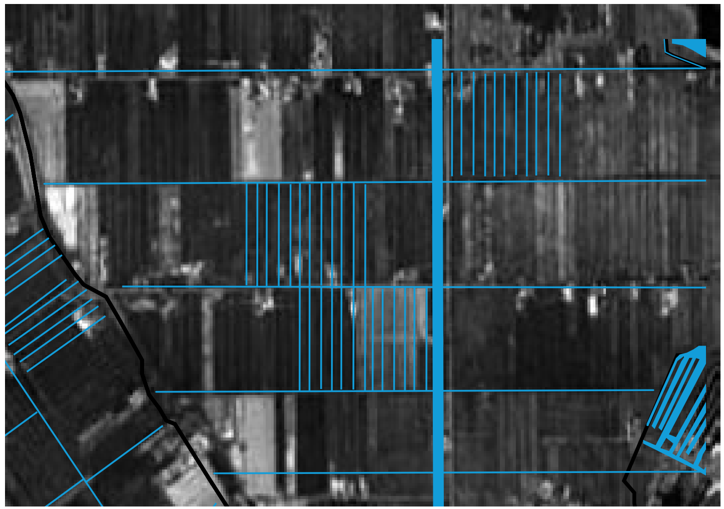
Over many centuries there have been few changes in the landscape and land use, apart from the fact that, as mentioned above, many mills have disappeared from the landscape. The peat grasslands are characterised by openness, panoramic views and uniform land use.

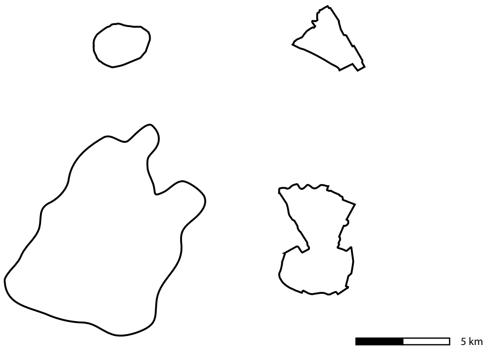
Because the peat soil is soft, the edges of the ditches are often irregular. This created space for plants from different vegetation stages between wet and dry land and for aquatic fauna in the water.[14] Peat polders are not easily accessible due to the wet, unstable ground and the large number of ditches. Small dams with various types of fencing are the furniture of the peat plots. Paths over embankments and dikes provide for an elevated position in the landscape and far-reaching views across the polder. The wetlands attract meadow birds.

A peat polder contains many weirs, dams and culverts. The culverts are rarely visible; they are in the ground. Weirs in the peatland usually consist of a simple plank: a water step. Small windmills or electric pumps are used when the water needs to be moved to a higher level from a low-lying part of the polder with a lower water level. Embankments, artworks and bridges are singular elements of the water system.

The height of the dikes and embankments forms spatial boundaries, an effect that is usually reinforced by planted vegetation. In combination with the pattern of the ditches and the waterworks, they reflect the historic struggle against the water.

In areas with more building development, the houses are situated on narrow reclaimed 'ribbons', and each property is accessed by a bridge. The main watercourse is often wide enough to enable small boats to enter the polder.



Contour lake-bed polders

◀

Province of South-Holland: fragment Zoetermeerse Meerpolder – regular grid parcelization

Province of Utrecht: fragment polder *1e bedijking* with winding dike on creek ridge, part of Ronde Venen - irregular grid parcelization

Province of Utrecht: fragment polder *1e bedijking* with winding dike on creek ridge, part of Ronde Venen - irregular grid parcelization

Province of Utrecht: fragment lake-bed polder Groot Mijdrecht with main vaart - grid parcelization

15 Reh, W., Steenbergen, C., Aten, D. (2005). *Zee van Land.* Stichting Uitgeverij Noord-Holland

Drainage patterns in lake-bed polders

The former sea or lake bed is treated as a plain and drainage is by means of a grid pattern. Parcelization in a lake-bed polder is rational and geometric. In agriculture there is an optimum plot size, which is dependent on the specific use and on technical know-how. This plot size is projected onto the polder plan as many times as possible. The reclamation pattern is ultimately designed on the drawing board, based on the specific details of the site and the programme for the polder.

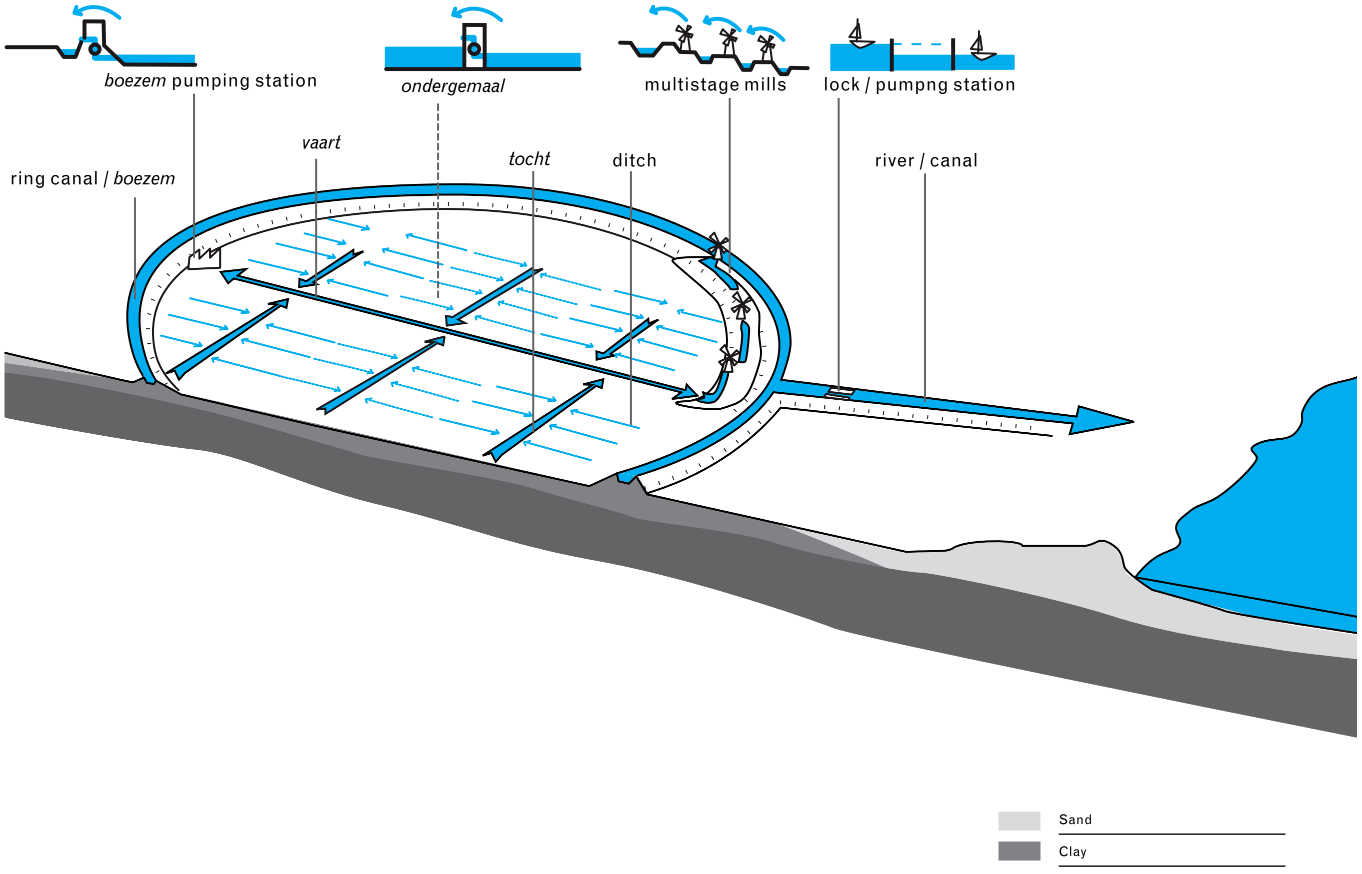
Advances in drainage techniques made it possible to reclaim ever larger expanses of water. Technical advances also meant that plot size could be increased, for example through the use of underground drains. When the design was implemented, modifications and adjustments were made as the work was carried out. The reclamation process often took several years. There are examples of polder designs that were not executed satisfactorily or ultimately could not be executed at all. The Naardermeer is a good example of this. The transformation from artificial lake to lake-bed polder failed as a result of persistent seepage. The area eventually became a unique natural landscape, where the forces of nature have partly obliterated the basic contours of the polder.[15]

The following drainage patterns can be distinguished in a lake-bed polder: irregular grid parcelization, regular grid parcelization, square grid parcelization and atypical parcelization. In principle, the drainage pattern in a lake-bed polder is based on grid parcelization because this is the most efficient method for draining a plain, the former natural or artificial lake.

Functioning and visual features of lake-bed polders

As in peat polders, the drainage of lake-bed polders takes place in a number of phases: the 'water sequence'. Each step in the sequence has its own characteristic form and materialisation, combined with typical built elements: the waterworks.

The water sequence in a lake-bed polder consists of ditches and watercourses (*tochten* and *vaarten*) that discharge water into the *boezem* via a pumping station. The average level of lake-bed polders is about 5.5 metres below the Amsterdam Ordnance Datum. The drainage process is hardly visible due to the low water level. The water level is, on average, more than 0.70 metres below ground level - a requirement for growing crops. The bed of the natural or artificial lake is usually clay, and ideal as agricultural land. Unlike the plot ditches, the large, wide water axes (the *tochten* and *vaarten*) are clearly visible in the polder. A *tocht* is a linking ditch between the polder ditches and polder *vaart*. The *vaarten* carry the water from the ditches and *tochten* to the pumping station. Ditches, *tochten* and *vaarten* can have the same water level. Due to the relief of the polder bed, there are usually differences in level within a ditch, between a ditch and *tocht*, within a *tocht*, between a *tocht* and *vaart*, or within a *vaart*.


boezem pumping station
ondergemaal
multistage mills
lock / pumpng station
vaart
tocht
ditch
river / canal
ring canal / boezem
Sand
Clay

Weirs, mills and pumping stations are essential for controlling the water level, as in peat polders. Because the effects of soil settlement are much smaller in the bed of a lake-bed polder, the position and number of waterworks in it are less likely to change than those in a peat polder. The polder and its waterworks are designed together. The positions of the waterworks in a lake-bed polder are therefore less improvised than in a peat polder.

The most notable elements of a lake-bed polder are polder pumps (or pumping stations in the case of large polders), the ring dike that is usually present and its ring canal. The depth of the polder and the difference in elevation from the surrounding land are clearly visible from the high ring dike. Depending on the size of the polder and the height of the point from which it is viewed, the openness and rational structure of the lake-bed polder mean that it is more easily recognised as a spatial entity than a peat polder of the same size.

Natural and artificial lakes are drained for two reasons: to prevent further land slippage and to create fertile farmland. In a lake-bed polder design the specific characteristics of a location, drainage pattern, plot size, road pattern, and the location of the farms are synchronized. The farm locations are usually spread across the polder. Areas built later (e.g. village or city expansion) usually have a different reclamation pattern. There are several reasons for this, including the construction method whereby a layer of sand several metres thick is sprayed onto the polder bed. The main watercourses in lake-bed polders are usually wide enough to be navigable. In some large lake-bed polders, the polder *vaart* is connected to the *boezem* network by means of sluices, and the difference in level between the polder and the *boezem* is clearly evident.

Conclusion

In this chapter we have presented a brief overview of the development of the polder landscape. Most of the elements discussed above can still be found in the landscape. Their function needs to be understood if we want to design new waterscapes as part of the polder landscape and its polder-*boezem* system. In the next chapter we will look at six exemplary polders and explain the technical functioning of the water system and the position of all the water elements within the polder-*boezem* system.

▸ pag 90

Pumping station Sisyfus with extended watercourse

Small watermill, *onderbemaling*

Pumping station Nederwaard with Archimedes' screw

Mill with paddle wheel in polder Langerak

Pumping station Southpolder seen from the watercourse

Onderbemaling in the Harlemmermeerpolder

Pumping station Southpolder, Delft

▸▸ pag 91

Sluice and lifting bridge in Leidschendam

Dam in the Alblas a peat river

Boezem and storm surge barrier near Krimpen a/d Ijssel

American windmotor: De Hercules, Zaandam Kalverpolder

Modern pumping station, Bentpolder

Flexible sluice in the Oude Waver

Impression: Pumping stations

The form of the polder water

All polders are drawn on the same scale:

Peat polder Kockengen
- Province of Utrecht
Lake-bed polder Bethune
- Province of Utrecht
Peat polder Ronde Hoep
- Province of North-Holland
Lake-bed polder Schermer
- Province of North-Holland
Peat polder complex Alblasserwaard
- Province of South-Holland
Lake-bed polder Noordoostpolder
- Province of Flevoland

Introduction

This chapter discusses three different examples of peat polders and three different examples of lake-bed polders, respectively. The polders are discussed in order of their size and of the degree of complexity of the water system, beginning with the smallest and least complex. The selection of polders is presented so as to give an accurate, diverse picture of the abundance of different forms of water adaptation that exist in the lowlands of the Netherlands. The sources relating to the polder landscape are '*The Polder Atlas of the Netherlands*', various hydrographic charts and the WIS; they form the basis for this chapter.[1]

The polders discussed in this chapter are the peat polders Kockengen and Ronde Hoep, and the lake-bed polders Bethune and Schermer. These polders were created by draining artificial and natural lakes that formed when the peat was excavated by human hands or as a result of wind erosion, respectively. In terms of water management, the Schermer, with its inner *boezem*, is – or, more accurately, was – one of the most interesting lake-bed polders. The third peat polder in the series, the Alblasserwaard, is in fact a polder complex, since it comprises several polders that drain into open water via the *boezem* system. The drainage through the *boezems* in the Alblasserwaard culminates more or less at a single point, namely at the spot where the adjoining river is at its lowest level, so that the polder water does not need to be pumped up to too great a height. Over time, a unique and interesting pump-drainage system has evolved.

The Noordoostpolder, the youngest and largest lake-bed polder in this series, belongs to the group of IJsselmeer polders. In order to create these modern polders, part of the IJsselmeer – which was a sea inlet before the Afsluitdijk causeway was built - was diked and drained.

Each polder is illustrated with an aerial photograph – a 'bird's eye view' – from '*The Polder Atlas of the Netherlands*'. The drawings of the discharge system show the position of the polder in the *boezem* system. The colours indicate whether the polder drains into open water directly or via a *boezem*. Particularly in the case of the polders situated further inland, the drainage water has a long way to travel before it reaches open water. Given the importance of safe water drainage, the *boezem* water can take different routes before it reaches the discharge point, the *boezem's* pumping station.

Two sections of the (topographical) map and/or an older map of each polder show how the landscape has changed over time. It is noticeable that the ditch pattern in the peat polders has hardly changed, and that, in the case of the lake-bed polders, there is very little difference between the plan drawings and the actual implementation of the water pattern. One could conclude from this that the water design is one of the main elements that determines the appearance of the polder. Only through more in-depth analysis does it become evident that the water system is subject to constant modification.

The water-level areas of the polder are shown in a diagram. Parts of the polder where secondary pumping is used are

1 Steenbergen, C., Reh, W., et al. (2009). *The Polder Atlas of the Netherlands.* THOTH


Amsterdam
Utrecht
Rotterdam

◂ Drawing of *boezem* and polder water of peat and lake-bed polders between Amsterdam, Rotterdam and Utrecht

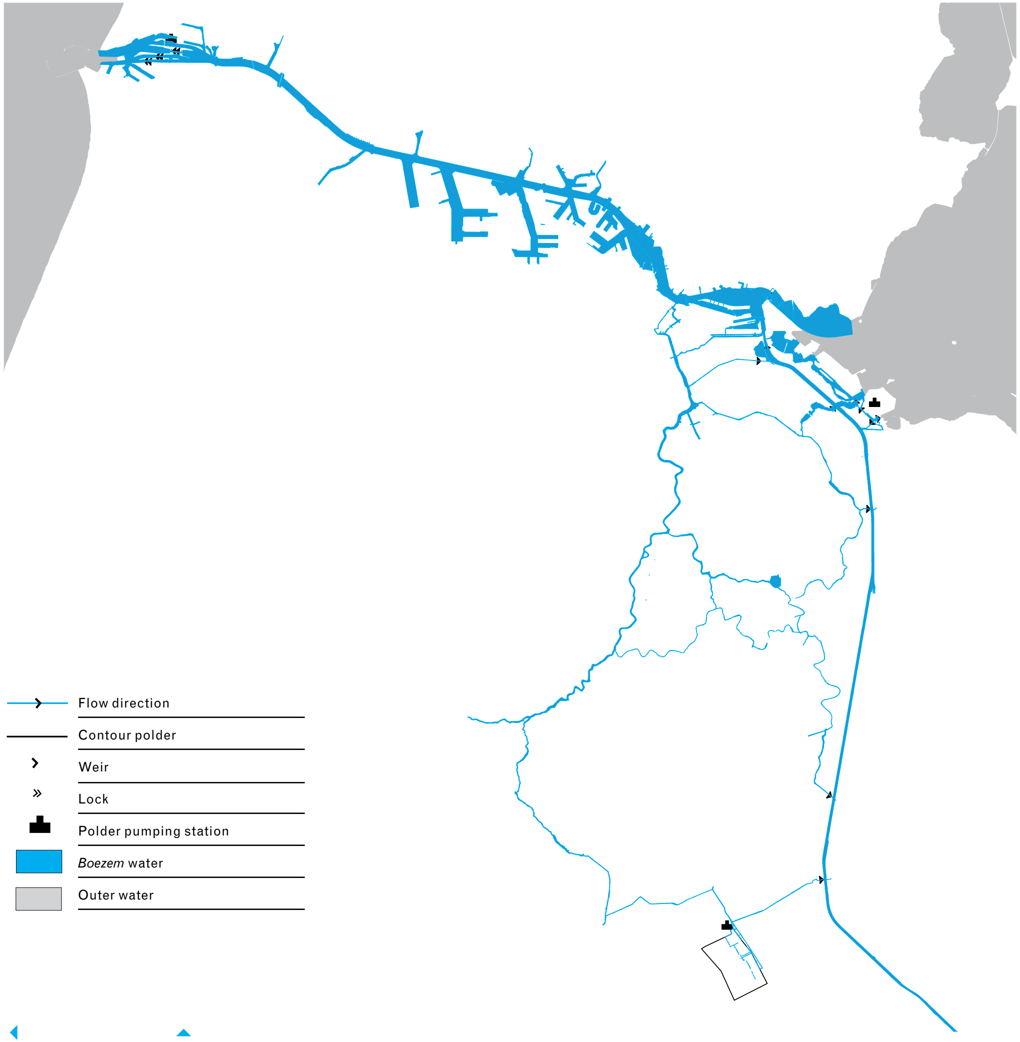
not illustrated, because they are usually installed by the user of the land and are not usually shown in drawings.

The relief map shows the elevations within the polder, and the elevation of the polder in relation to the surrounding landscape. If one compares the maps of the six polders, it is evident that the contour of a lake-bed polder is - as a result of its position in relation to the surrounding area - cut more sharply into the landscape, and is therefore more visible than the contour of the peat polders. Lake-bed polders are therefore clearly recognisable as a spatial entity in the landscape.

In addition to the contour map, the drainage system of the polder is also illustrated; arrows indicate the path that the water follows as it flows out. The analysis is drawn on an abstraction of the soil map, and hence illustrates how the natural landscape influences the water pattern. As mentioned above, Alblasserwaard is not a polder but a polder complex. This can be clearly seen from the dozens of pumping stations and the *boezems* in the drawing of the drainage system.

In the spatial analysis drawing of the polder, several interesting stages are shown in the system of water management in each polder. Water elements, such as a weir, sluice, inlet or pumping station, are always sited on ridges in the natural underlay.
The water elements that are present – the drainage pattern, dike, *boezem*, pumping station, watercourses (*vaart*, *wetering*, ditch), weir, inlet, culvert, bridges etc. - are drawn and described, and illustrated with photographs. The specific form of each water element in its specific location is brought ‘into view’ and explained. Most of the water elements in the polders have a technical origin, but some of them are more than that; they have also been adapted from the perspective of landscape architecture.

In the conclusion to this chapter we make suggestions – using the classical water features from garden architecture in Chapter 1 – for a landscape-architectural adaptation of polder water.



◂ Aerial photo of polder Kock-engen

▴ Discharge sys-tem of polder Kockengen

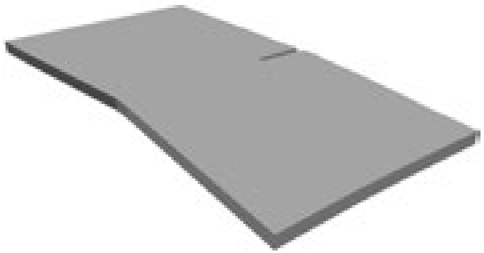
Kockengen Polder

- peat polder: mean elevation 1.40 metres below Amsterdam Ordnance Datum
- area: 341 hectares
- prototype of the most simple form of peat polder
- reclaimed from the 12th century onwards, pump drainage from the early 15th century
- original bed: bog peat
- Regional Water Authority: Stichtse Rijn-landen
- *boezem* area: Amstel
- 1 peilvak (designated-water-level area)
- fixed water-level management around
- built areas, dynamic water-level manage-ment in the polder [2]
drainage sequence: ditch – a perpen-
- dicular *wetering* - the pumping station is outside the polder and also serves the Teckop and Spengen polders - discharges water to a higher canal (the *boezem*)

2 Water-level Decree (Peilbesluit, 2007). Kockengen


SPENGEN
POLDER
Kockengen
ZUIDEINDE
KOCKENGENSCHE
POLDER
POLDER
GERVERSKOPSCHE
1 km


Spengen
Portengense Brug
Polder
Portengen
Kockengen
Kockengen
Polder
Kockengen
Teckop
Teckop
Polder
Gerverscop
1 km



Topographical map 1920 and 2009 of polder Kockengen

Drawing of *peilvak* polder Kockengen

Kockengen Polder was developed along the eastern bank of a peat stream in the peat area of north-west Utrecht. Reclamation took place from the 11th to 13th centuries. Ditches were dug to convert the existing marshy woodland into fields (later meadows). At least 20 mills were needed to drain the polders Kockengen and Spengen (a polder to the north of the Kockengen polder). Later, it was possible to reduce this number to 2.[3] It was not permitted to discharge water from the Kockengen polder via the province of Utrecht. For this reason, the Bijleveld was constructed in 1413 next to the Heycop canal, which was excavated in 1385 to drain the Utrecht polders. The Bijleveld not only carried away the excess water from the polder, but also provided a good navigable route between the Oude Rijn and the Amstel river. The Heycop linked the Oude Rijn and the Vecht.[4] The village of Kockengen benefited from its location between the two canals and went on to prosper. The northern section of the Bijleveld – the connection to the Amstel – disappeared in the 18th century when the Ronde Venen area was stripped of peat and drained.

Discharge and dike form

For a long time the canals functioned alongside each other with different water levels, presided over by separate water authorities, but they are now linked and have the same water level. The polder is bordered on the south and west sides by the Hollandse Kade, and on the north side by a peat dike. The Bijleveld, the discharge canal, is on the eastern edge of the polder. The water is carried from the Bijleveld to the Amsterdam-Rhine canal, and from there to the IJ near Amsterdam, or discharged into the North Sea via the North Sea Canal.

The Hollandse Kade is many kilometres long. It functions as a divide and zigzags through the landscape, past peat polders, from the Nieuwkoopse Plassen lakes to De Haeck.

Water pattern

Kockengen Polder is a good example of '*cope*'-reclamation. Together with the other polders, it forms a chessboard pattern with highly uniform strips of reclaimed land (112 x 1250 metres) in various blocks,[5] which are positioned pragmatically in relation to each other. The width and level of the water in the ditches and in the *wetering* at right angles to them make it clearly visible. A second *wetering* in the north of the polder, parallel to the ditch network, carries the water from the Teckop polder to the Kockengen polder. The water drains from the polder unseen, via a culvert and sluice.

Waterworks

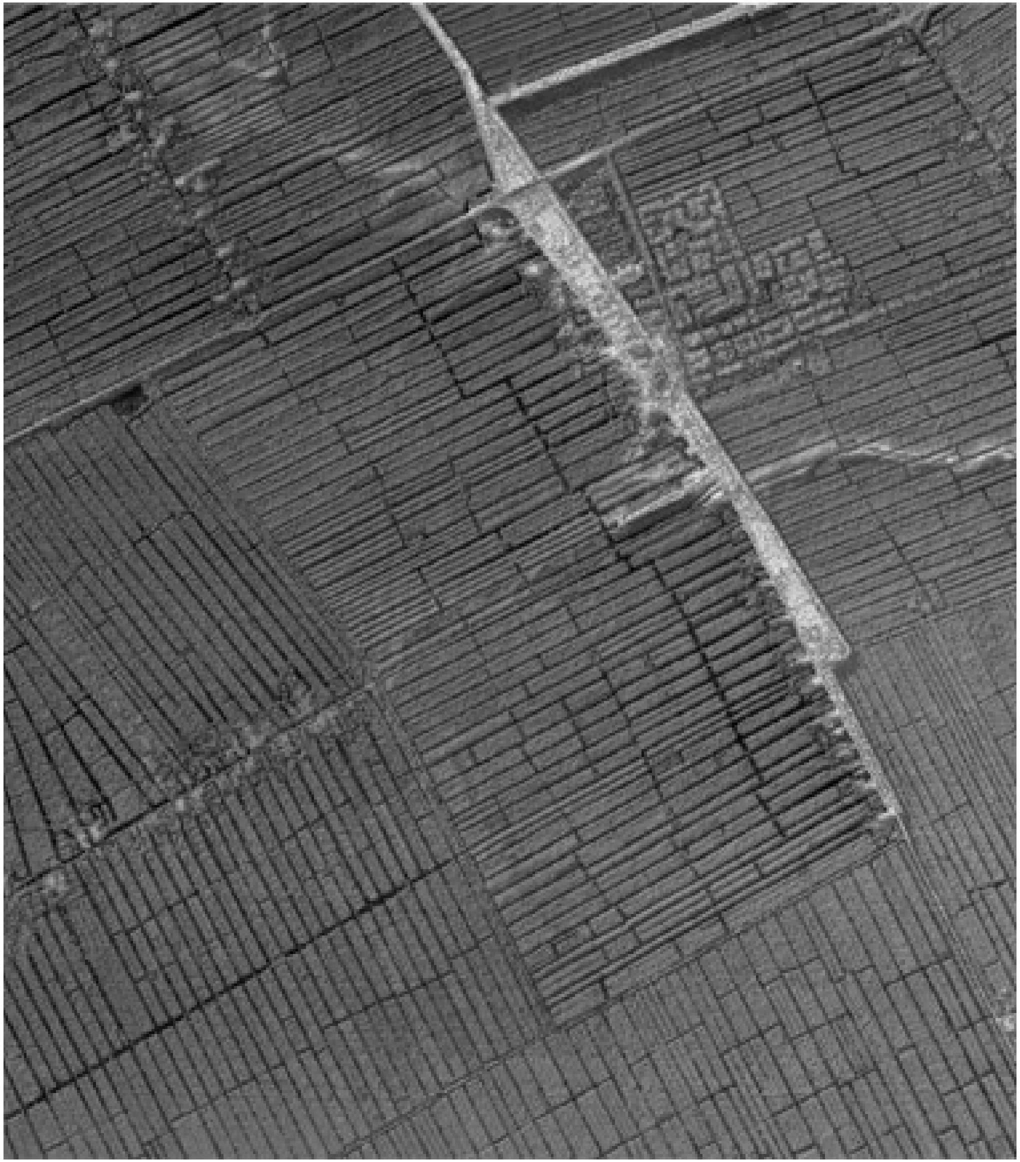
The pump drainage in the polder was reviewed during the large-scale land reallocation processes of the 1960s, aimed at modernising the agricultural lands. Until 1960, the Kockengen mill, which is still standing and can be used to aid drainage if required, drained the 341-hectare polder.[6] It was linked to the *boezem* via the mill race on a higher level, situated on an old natural levee. This meant that it was possible to

3 Leeuwen, B. van, (1993). *De Molens van Spengen en Kockengen.* Stichting De Utrechtse Molens (SDUM)

4 www.regiocanon.nl

5 Brand, H., Brand, J. (red.) (1990). *Het Utrechts landschap. Natuurlijk hart van Nederland.* Stichting Het Utrechts Landschap

6 Leeuwen, B. van (1993). *De Molens van Spengen en Kockengen.* Stichting De Utrechtse Molens (SDUM)



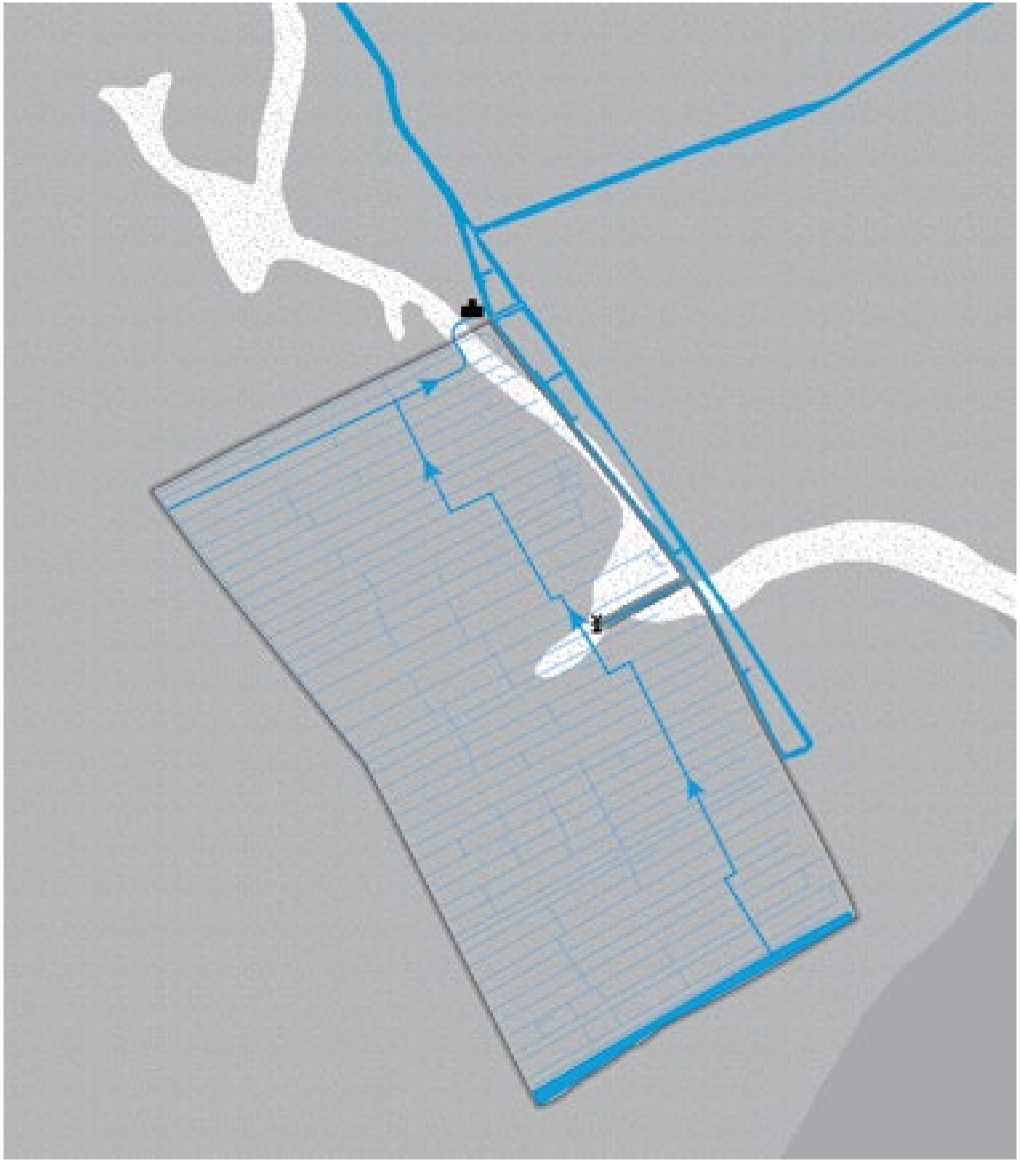
◂ Altitude map of polder Kock-engen

▸ Water pattern and discharge direction of polder Kock-engen on the natural land-scape

	Dike
	Polder
	Discharge direction
	Windmill
	Pumping station
	Natural river levee
	Peat
	(Old) clay

7 Buitelaar, A.L.P. (1993). *De Stichtse Ministerialiteit en de ontginningen in de Utrechtse Vechtstreek. In: Middeleeuwse studies en bronnen,* Vol. XXXVII. Uitgeverij Verloren

8 Steegh, A. (1985). *Monumentenatlas van Nederland. 1100 historische nederzet-tingen in kaart.* De Walburg Pers.

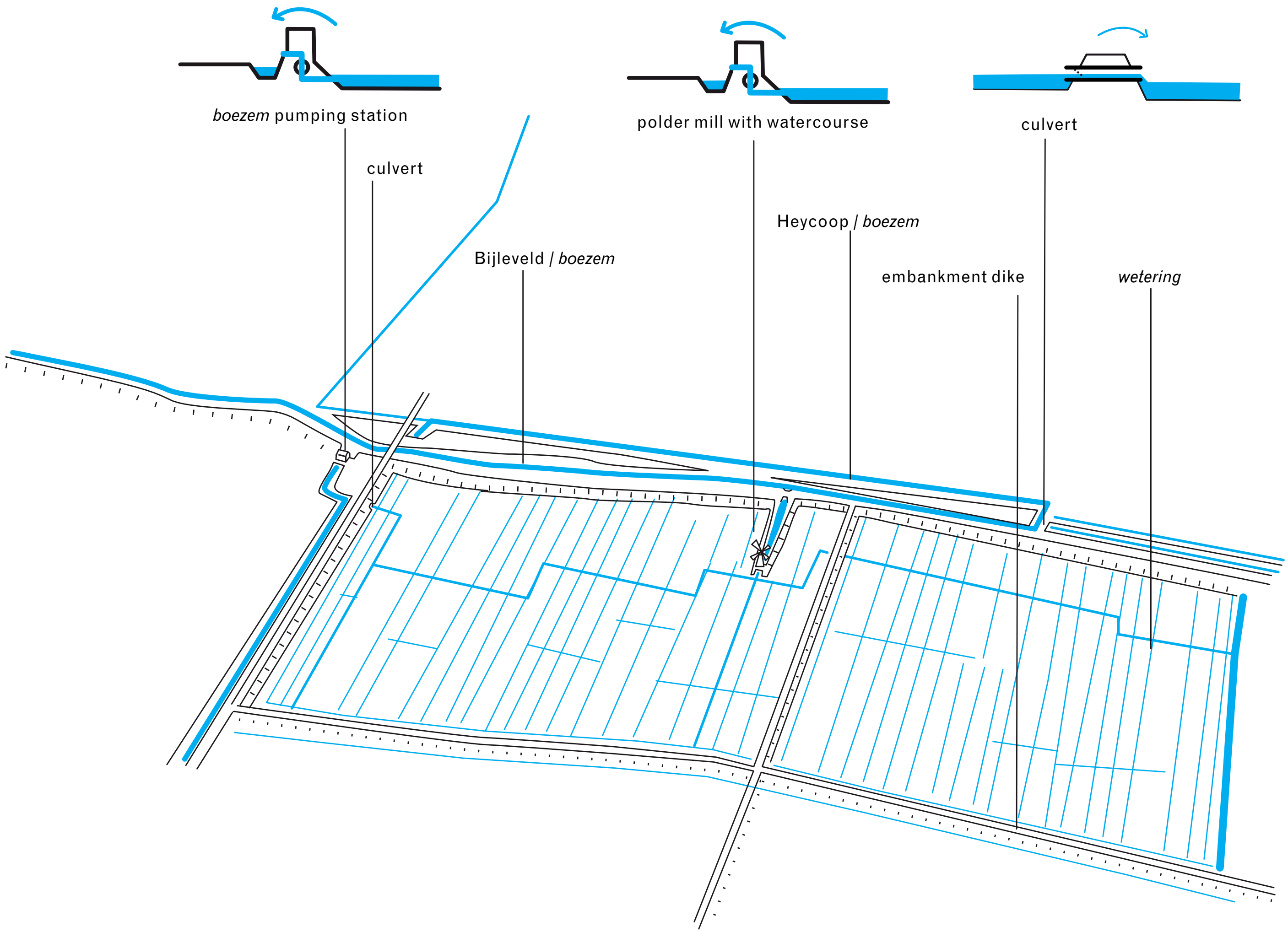


move the pumping-out point to the middle of the polder. The mill is a listed building and is managed by the Stichting Utrechtse Molens. Like the Spengen mill, the Kockengen mill was replaced by an electric pumping station just north of Kockengen Polder, within the boundaries of Spengen Polder. This mill has also been preserved.[7]

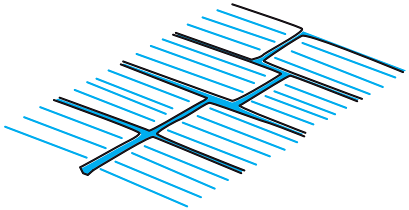
The *wetering* in Kockengen Polder is given a strong spatial emphasis by dozens of bridges, which provide access to the land behind. Culverts link the smaller transverse ditches, giving the farmer and cattle access to the plots of land. These land connections are also known as 'cow dams'.

Recently a spectacularly long retaining wall was constructed in the *boezem*, forming a high-water weir. When the *boezem* water level rises by 20 cm the weir closes, thereby protecting the old low-lying area of the village between the canals. The construction of the weir reduced the storage capacity of the *boezem* and an additional 19 hectares of land are needed in the area for peak-flow storage. Part of the polder in the area will therefore be designated for this purpose.[8]

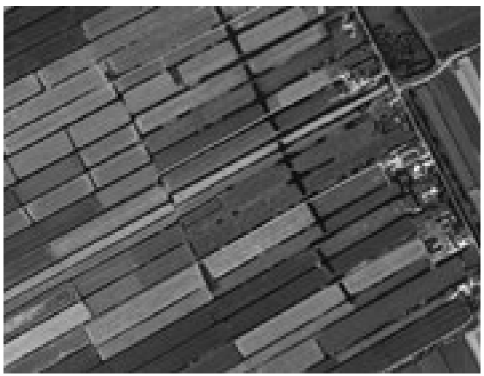
Technical water elements of polder Kockengen



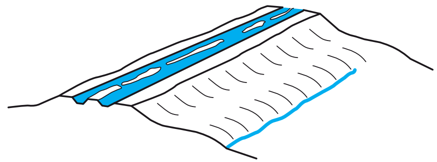
Water pattern
form: strips (‘*slagen*’), ‘*cope*’-parcelisation



Strip land parcelling is the most common form of peatland allocation. When the level of the reclamation base sank due to settlement, a new watercourse (*wetering*) was dug in the lowest part of the polder (approximately in the middle of the strip of land), which caused the water in the ditches to flow in the opposite direction. The ditches in this polder are wider than is usual for a peat polder, and therefore clearly visible.

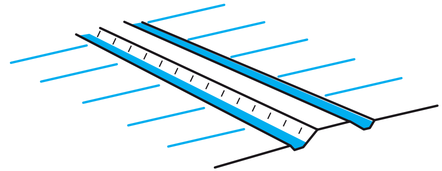


Canal – *boezem*
movement: flowing
form: straight line of water



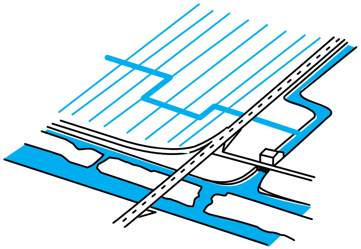
The long, straight canal is elevated in the landscape in relation to the polder. Today the Bijleveld and the Heycop, which used to belong to two separate water systems, are linked in certain places via a *waterplein* (‘water square’).

Embankment – dike
form: straight line dividing ridge



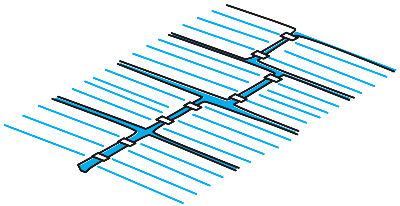
The embankment, consisting of old peatland, describes the polder boundary in the west. Although the embankment is elevated in relation to the landscape, it is much lower than the dike in the east. The Hollandse Kade is part of a long north-south line that passes many polders. The embankment is clearly visible, thanks to consistent vegetation growth, and is mainly used as a cycling and walking route.

Pumping station
movement: from low to high
form: enclosed waterwork



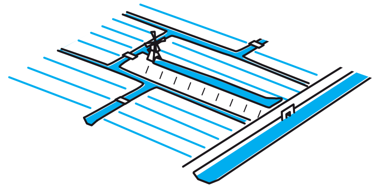
The mills of Kockengen and Spengen (a neighbouring polder) were replaced by an electric pumping station in 1961. The position of the new station along the canal is relatively arbitrary, and it is no longer directly linked to the polder drainage system. The Teckop polder also drains via the pumping station, via the Kockengen polder.

Watercourse (*wetering*) with small bridges
movement: still or mechanically flowing
form: line of water with perpendicular linking open water network that accentuates the line



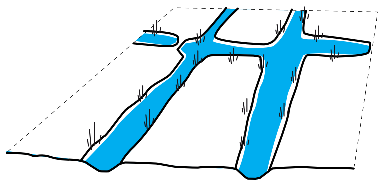
The ditches are connected to the broad *wetering* at right angles and the water level in the ditches and *wetering* are the same. The *wetering* is clearly visible and is accentu-ated by dozens of small concrete bridges that provide access to the plots of land on the other side. The *wetering* runs through a connective conduit, where it connects at right angles to the new pumping station.

Mill with millrace on dike
movement: from low to high
form: moving, visible vertical waterwork at the end of an elevated line of water



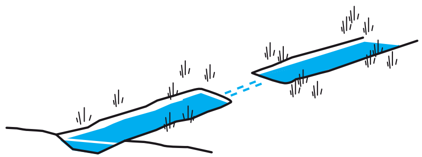
The original pumping station, the old water mill, is used as a reserve mill. It is positioned on a natural clay levee in the middle of the polder. The water is discharged into the *boezem* by means of a raised millrace on the level of the *boezem*.

Peat ditch
movement: still or mechanically flowing
form: narrow line of water



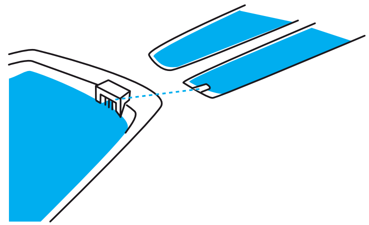
Today, water levels in the peat ditches are kept high in order to protect the meadows from further settlement. The ditches – which are, on average, 0.6 metres deep and 2.5 metres wide – have to be dredged every three years in order to maintain the drainage function. The edges of the peat ditches are irregular.

Culvert and *koedam* (cow dam)
movement: flowing
form: enclosed waterwork

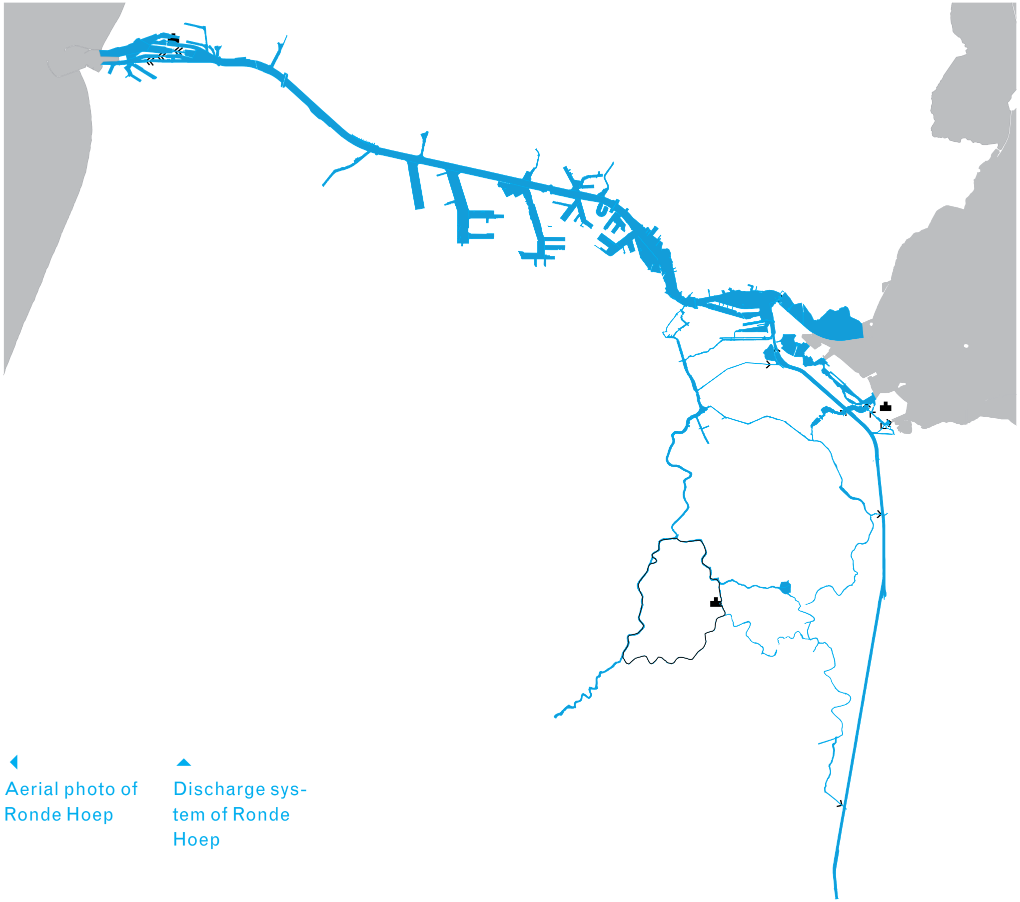


Culverts are cylindrical water channels under a dike, dam or road, or even under another watercourse. They usually connect areas of the same water level.

Culvert
movement: flowing and overflowing
form: enclosed and projecting waterwork



In this type of culvert, which carries the water out of the polder on the drainage side, the end of the culvert is designed and therefore highly articulated.



◀ Aerial photo of Ronde Hoep

▲ Discharge system of Ronde Hoep

Ronde Hoep

- peat polder: mean elevation 2.00 metres below Amsterdam Ordnance Datum
- area: 1,266 hectares
- a striking round polder with fan parcelization, encircled by peat rivers; in the middle of the polder there is a nature reserve with an independent water level
- reclaimed from the end of the 10th century onwards, drained by pumps from 1407
- soil: wood peat or reed peat
- Regional Water Authority: Amstel, Gooi & Vecht
- *boezem* area: Amstel
- 5 designated-water-level areas; the aim is to reduce this number
- Drainage sequence: ditch, partly fan-shaped with transverse connections – with, at right angles to it, a ring-shaped watercourse (*wetering*) with a side branch to the pumping station – drainage to a peat river (*boezem*) situated on a higher level

Flow direction
Contour polder
Weir
Lock
Polder pumping station
Boezem water
Outer water


Ouderkerk a/d Amstel
Polder
225 ha
zp-2.50
-2.2
42 ha
zp-2.70
wp-2.75
75 ha
p-4.00
695 ha
zp-5.60
wp-5.70
Boven
Ringsloot
Amstel
wetering
Molenwetering
zp-4.70
wp-4.80
Polder
-2.1
965 ha
zp-2.70
wp-2.75
Rondehoep
Meensloot
Molen
Molenwetering
Stokkelaar
125 ha
zp-2.40
wp-2.50
Oostdijk
300 ha
zp-2.42
wp-2.51
32 ha
-1.9
-2.2

Legend *waterstaatskaart* (map of water-system) 5th edition of Ronde Hoep

[pumping station symbol]	Pumping station, code provides technical information
[small pumping station symbol]	Pumping station, smaller than 6m3/minute
[windmill symbol]	Windmill
△	Sewage purification
zp 0.10	Summer level
wp 0.10	Winter level
335 ha	Area drainage unit

◂ Detail *Water-staatskaart* (map of water system) 5th edition of Ronde Hoep

Until the 14th century, the rainwater drained freely into the surrounding rivers. As a result of settlement, the land became waterlogged and around 1407 the polder had to be embanked and drained. The ditch pattern still reflects the mediaeval reclamation pattern. Until 1637, the water was pumped out of the polder by 36 small mills. In about 1637 the number of mills could be reduced to 3, following the excavation of a ring watercourse (*wetering*). At the end of the 17th century it became necessary to construct the ring dike along the contours of the peat rivers.

Discharge and dike form

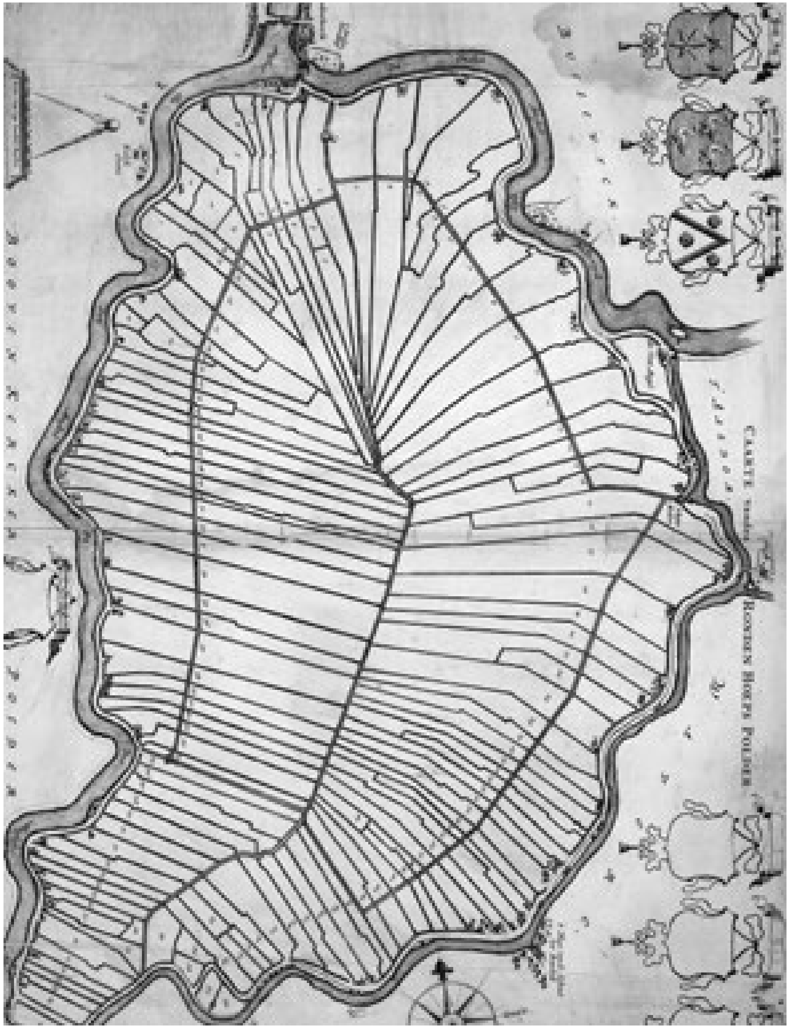
The polder is entirely surrounded by a number of peat rivers, whose dikes are composed of a combination of clay and peat. Over time, the edges of the peat rivers were heightened, forming dikes. They retained their characteristic meandering form. The original peat mound is still visible in the form of the polder. From the dike it is possible to look down on the polder in many places and experience its vastness, but it is not possible to walk into it. Water is discharged on the east side of the polder, where it is carried by the peat rivers the Waver and Gein towards the Amsterdam-Rhine canal, from where it discharges into the IJsselmeer. In the south of the Ronde Hoep in the Oude Waver river there is a sluice that can be used to divide the Amstel *boezem* into compartments when water levels are high.

Because there is little building development on the Ronde Hoep polder, it was recently designated as an emergency storage polder for Amsterdam West and the Amstelland *boezem*. This means that, once every 100 years, the polder can be inundated with approximately 50 cm of water for a period of up to two weeks.

The patters of ditches, *tochten* and *vaarten*

Over the years, the pattern of the ditches has changed little, apart from the northern point of the polder at Ouderkerk aan de Amstel, north of the A9 motorway. The ditch pattern still reflects the mediaeval pattern of peat-mound reclamation, with plots of land laid out in a characteristic fan shape. The drainage system itself has been modified several times over the years. The most simple drainage pattern consisted of two water-level areas, both draining via a mill, one in the west into the Amstel, and one in the east into the Oude Waver. As a result of uneven settlement, the polder is now divided into five designated-water-level areas. A ditch in each water-level area has been widened so that water from the adjacent higher water-level area can be discharged more quickly. The pattern is therefore characterised by ditches of different widths. The ring-shaped watercourse (*wetering*) carries the water to the millrace and then to the pumping station, which appears to be arbitrarily situated in relation to the *boezem*. The concentric form of the *wetering* between the edge and centre of the polder echoes the shape of the polder.

In the centre of the polder, a nature reserve is being developed in order to



N
1 km

Ouderkerk a/d Amstel
Polder de Rondehoep
Gemeente Ouder-Amstel
De Zwarte Kat
Polder de Rondehoep
Gemeente Ouder-Amstel
Waver
Gemaal

N
1 km

◀ Topographical map 17e century and 2007 of Ronde Hoep

▲ Drawing of *peilvak* Ronde Hoep

▲▲ 3 generations of pumping stations next to each other

conserve and reinforce populations of unique flora and fauna in the polder. This part is separate from the drainage system of the meadows. The ditches have been dammed-up, and water discharges into the rest of the polder via the Meentsloot, which runs through the centre of the polder. Clean water is channelled from a local nature reserve into the new central area via an underground pipeline.

As a result of the construction of the motorway and the expansion of Ouderkerk a/d Amstel, the northern section of the polder is now separate from the agricultural polder and has its own water and drainage system.

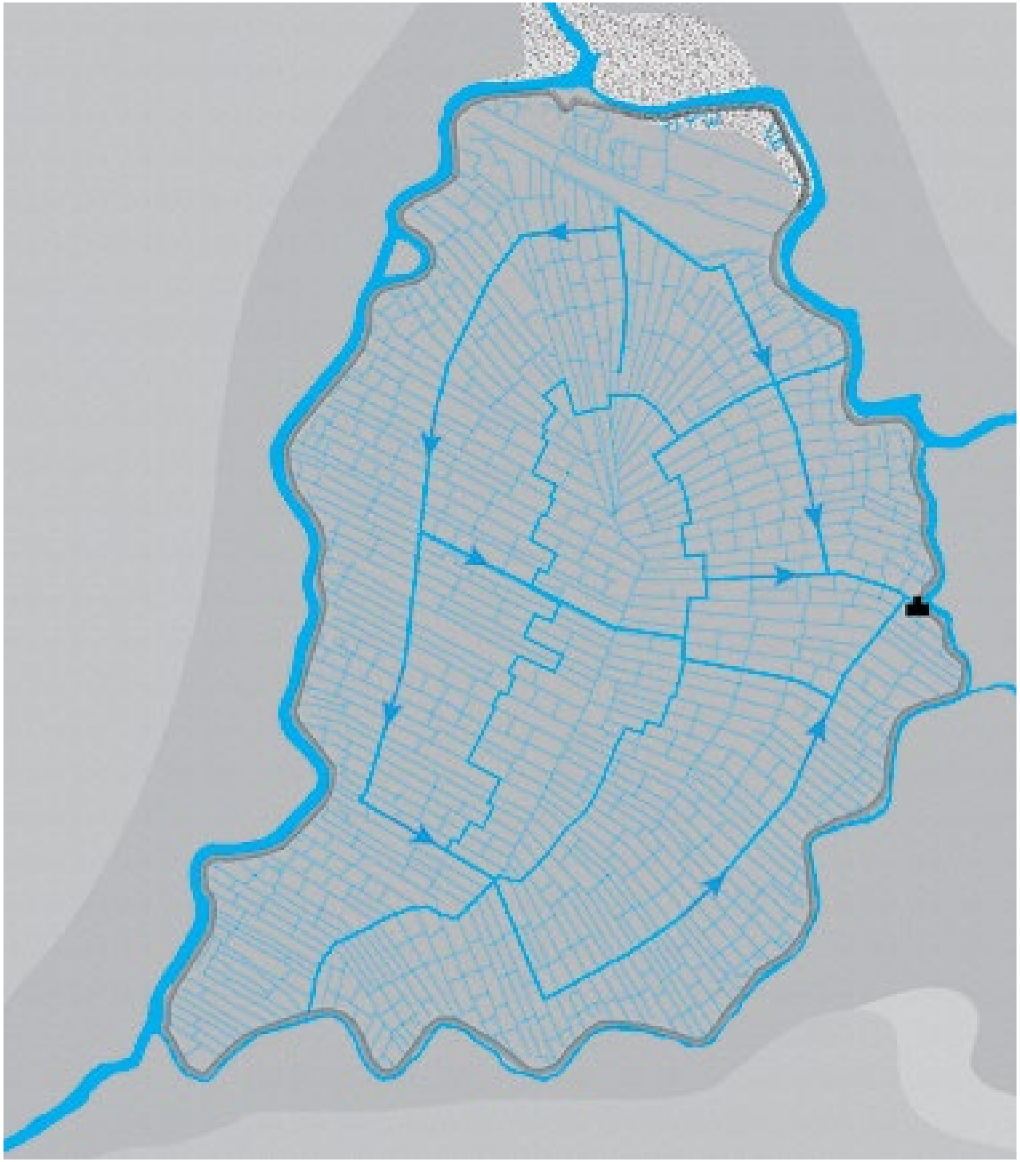
Waterworks

In contrast to a lake-bed polder, the waterworks in a peat polder are more numerous but less visible. As a result of the soil composition in a peat polder, there is considerable settlement as water drains away, which means that the water system requires constant modifications. The parcels of land are interconnected over the water; the hundreds of culverts link up the water into a continuous network. Simple weirs consisting of a wooden, steel or concrete board across a ditch bridge differences in elevation in the terrain. These weirs are usually located on the edge of a water-level area, and they articulate the relief of the polder landscape.

Almost all the polder water, except for that in the northern section next to the motorway, is discharged into the Waver by means of an electric pumping station. At this location there are three generations of pumping stations. Initially the polder was drained by three water mills spread out along the edge of the polder. The water mills were replaced with Archimedes' screws, and in 1913 the Waver mill was replaced by a diesel-powered pumping station. The pumping capacity of the installation increased thanks to technical advances. This meant that, although fewer pumping stations were needed, it was possible to discharge more water, making the other mills superfluous. In 1943, the diesel engine was replaced by an electric one, and in 1995 a new pumping station was installed next to the old one. As a result of the improved pump technology, the rate of settlement increased. Today, in order to prevent this, the water levels have been raised again. The wetter the soil, the less it will settle. Livestock farmers are obviously less than happy about these measures.

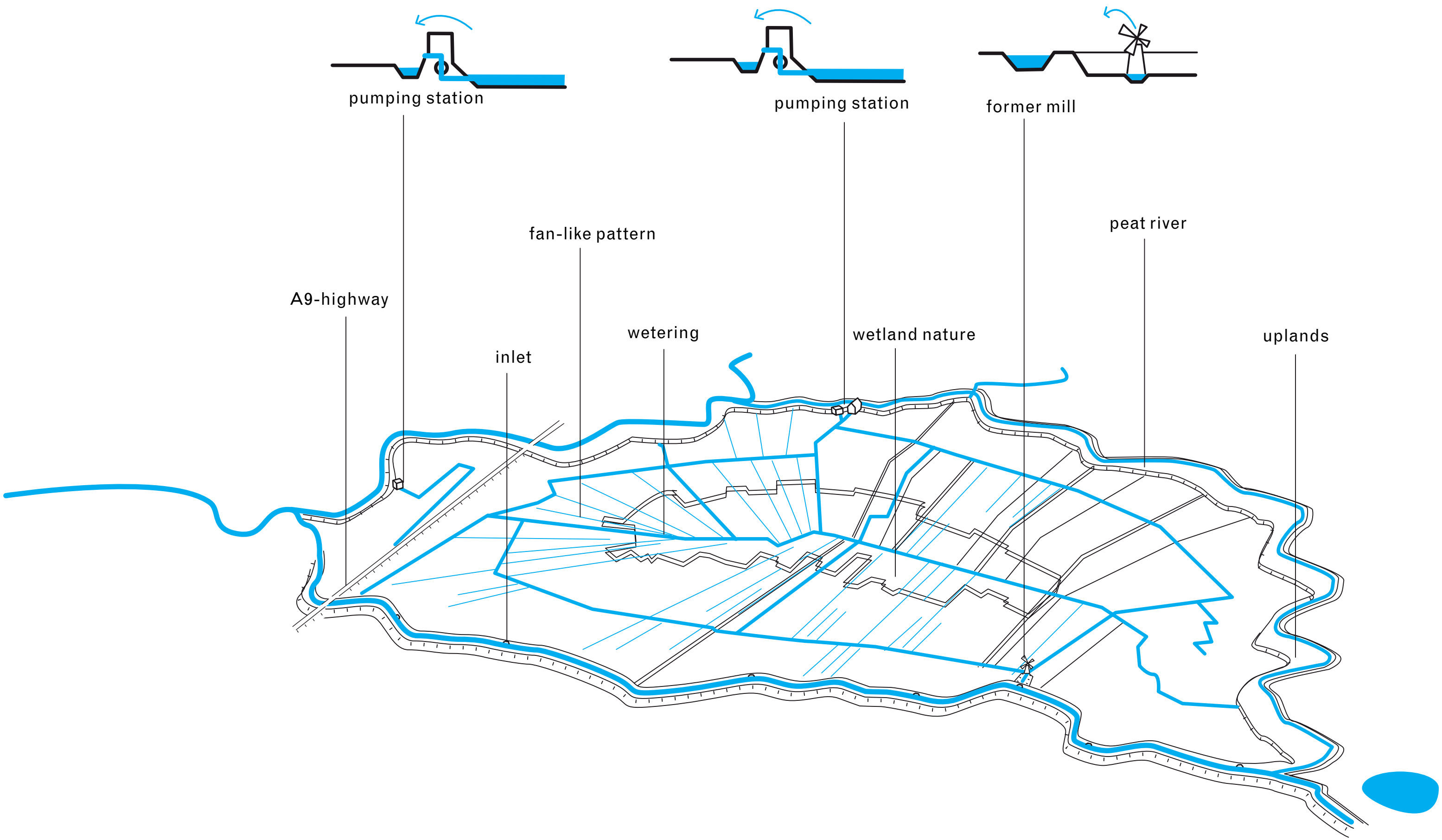
Along the edges of the polder there are 25 inlets through which water from the *boezem* is brought into the polder in order to maintain the high water level near the dike, where the farms are located. This prevents the foundations of the farms from rotting and slows down the settlement process. The inlets also bring water into the polder during the summer.

Altitude map of Ronde Hoep

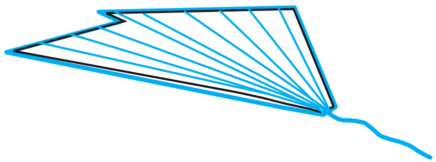


Water pattern and discharge direction of Ronde Hoep projected on the natural landscape

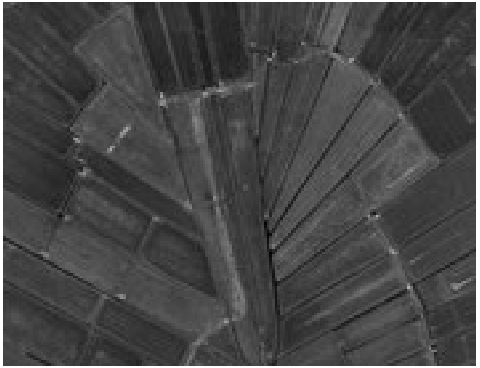
Technical water elements of polder complex Ronde Hoep



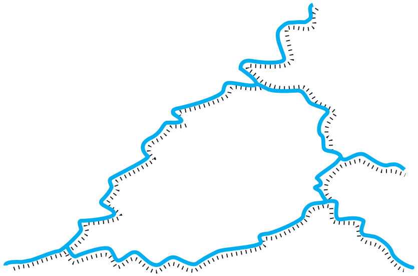
Water pattern
form: fan-like pattern



Individual farmers who took a pragmatic approach, starting from the surrounding peat streams, reclaimed the polder. The ditches converged in the middle like the spokes of a wheel, a pattern that was dictated by the circular form of the peat mound.

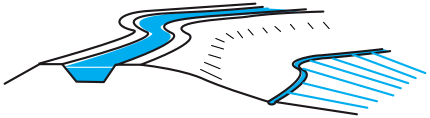


Peat river – *boezem*
movement: flowing
form: meandering line of water



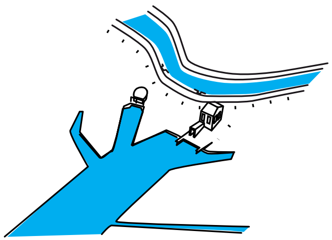
The polder is surrounded on all sides by meandering peat rivers, which are on a higher level than the polder and are hardly affected by settlement. The water levels in the *boezem* are high; water storage capacity is insufficient.

Peat dike
form: meandering line



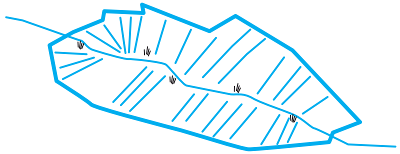
The dikes of the rivers border the polder on all sides and define it as a spatial entity. Over time, the dikes have been reinforced and made higher many times. The profile of a dike changes according to the depth of the adjacent polder and the soil composition at the site of the dike.

Pumping station
movement: from low to high
form: enclosed waterwork



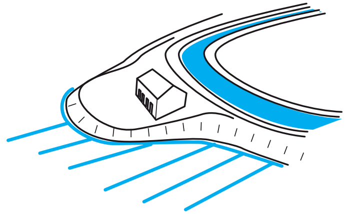
The Ronde Hoep pumping station is sited where the ring ditch almost touches the *boezem*. Next to the pumping station there are two older stations that are no longer in use. A bypass has been dug from the watercourse (*wetering*) for the new electric pumping station.

Ring-ditch *wetering*
movement: still or mechanically flowing
form: ring of water



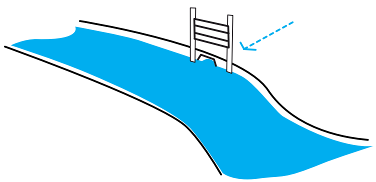
The ring ditch is a specific element that echoes the shape of the polder inside the polder and provides efficient drainage. Before the nature reserve was created in the middle of the polder, the middle ditch was also part of the main drainage channel. A piece of it has now been cut out and is part of the independently regulated central area.

Farm on the edge of the peat
form: mound/dike extension



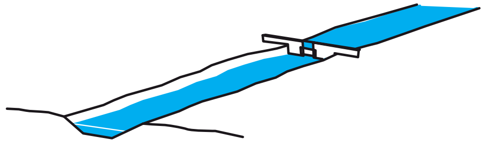
The farms are located on the edge, on and in the peat dike of the polder. The access road is on the dike, next to the peat river. The access points to the farms are sometimes lower than the road, because the height of the dike has been raised. Apart from the edges, the polder is entirely undeveloped and open.

Inlet
movement: blocking or falling
form: encapsulating waterwork



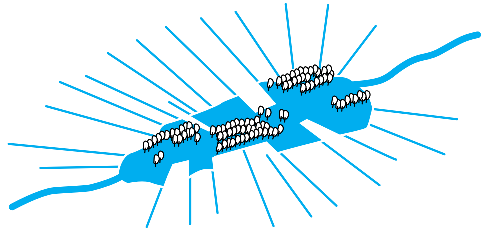
Water from the *boezem* is let in to prevent subsidence of the wider parts of the dike, where there are buildings. This prevents the foundations of the buildings from rotting. The *boezem* water seeps into the ground through 25 barely visible inlets. The flow of water can be controlled with gates.

Weir
movement: blocking or falling
form: separating small waterwork



In previous centuries, water was continuously drained from the Ronde Hoep, which caused the land to sink several metres. The relief of the polder bed is reflected in the small weirs constructed by farmers at the agreed, permitted level.

Nature island
form: island



The middle part of the polder is designated as a nature island. All the ditches have been dammed and separated from the polder water. Clean water is let in via an underground pipeline. The water level can vary with the seasons. The changing conditions create a suitable environment for rare animals and plants.

Aerial photo of polder complex Alblasserwaard

Discharge system of polder complex Alblasserwaard

Alblasserwaard

- peat-polder complex, comprising more than 20 polders
- peat polders: mean elevation 1.50 metres below Amsterdam Ordnance Datum
- area: 28,000 hectares
- river polder, belongs to the river region in terms of soil type, the reclamation method shows all the characteristics of the peat landscape
- reclamation from the end of the 11th century onwards, diked between the 12th and 13th centuries, drained from the beginning of the 17th century
- soil: very diverse, tidal deposits of clay and partly on peat in the west, also peatland, and river clay in the east
- Regional Water Authority: Rivierenland
- *boezem* area: Lek and Maas
- natural elevation on the east side due to the river's former course
- discharge sequence: ditch, series of *weteringen* at ditch level, or excavated *weteringen* and peat rivers (Alblas and Giessen) at interlinking-*boezem* level – the pumping stations are on the deepest level in the polder complex, drainage from here to high *boezem* or pond – discharge via sluice when water levels are low or by pumping into open water (the Lek)

Flow direction
Contour polder
Weir
Lock
Polder pumping station
Boezem water
Outer water


Schuwacht
in ontwerp
Krimpen
a/d Lek
in ontwerp
75 ha
Hoge
Boezem
van de
Nederwaard
32 ha
070-23
27 ha
070-23
Nieuw-
Lekkerland
Hoge Boezem
van de Overwaard
Polder
-1.5
90 ha
Polder
-1.5 190 ha
zp-2.00
wp-2.10
29 ha
Polder
160 ha
Kortland
zp-2.08
wp-2.18
ALBLASSERD
125 ha
30 ha
Polder
50 ha
zp-1.55
wp-1.80
85 ha
zp-0.35
wp-0.70
NOORD
Oude Molen
Oud-

1 km

Legend *waterstaatskaart* (map of water-system) 5th edition of Alblasserwaard

	Pumping station, code provides technical information
	Pumping station, smaller than 6m3/minute
	Windmill
△	Sewage purification
zp 0.10	Summer level
wp 0.10	Winter level
335 ha	Area drainage unit

Detail *Waterstaatskaart* (map of water system) polder complex Alblasserwaard

Reclamation began with the land near the rivers in the 10th century. There was a marsh in the centre of the river area between the Lek and Merwede. As a result of subsidence, the direction of water discharge reversed, and the water drained away via peat rivers and excavated *weteringen* in the centre of the polder complex. The eastern part of the area, the Overwaard, drained into the Merwede via the Giessen and the western part, the Nederwaard, into the Noord via the Alblas. From 1365 onwards, due to land settlement, drainage into the Merwede was not even possible any more and the Overwaard was channelled to the northwest of the Alblasserwaard. Drainage from the Alblas was also redirected to the lowest point of the river Lek, by means of a separate, parallel canal.

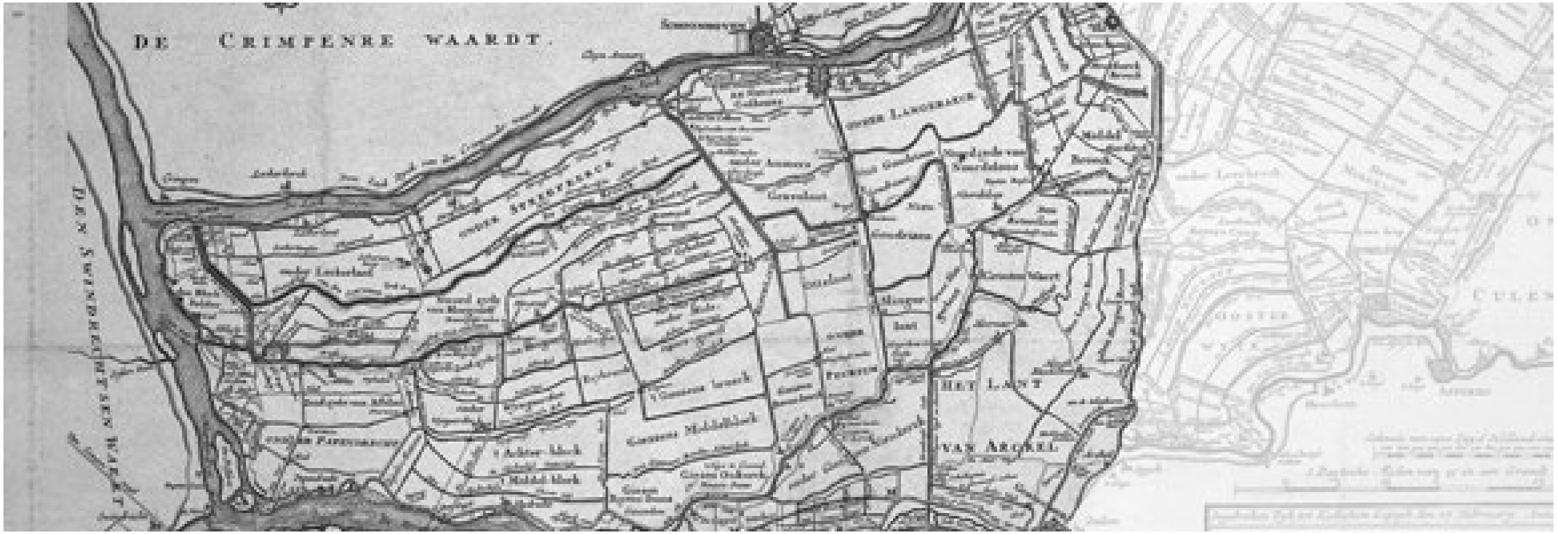
Discharge and dike form

The Alblasserwaard is bordered by diked watercourses: the Oude Zederik – dug in 1370 – in the west, the rivers Linge, Boven Merwede and Beneden Merwede in the south and east of the polder, and the Lek in the north. All the polders drain into open water through the *boezem*, via 2 partly excavated interlinking *boezems* at the westernmost point of the Alblasserwaard. The whole Alblasserwaard drains into the Lek, which is directly linked to the sea, via three *boezem* pumping station that are positioned close together. Two electric pumping stations, both equipped with large Archimedes' screws, are positioned at the upper end of the parallel low-lying *boezems*.

These *boezems* – interlinking *boezems* – originally belonged to the two Regional Water Authorities of Overwaard and Nederwaard. The water was pumped from the low Overwaard *boezem* to the higher Overwaard *boezem*. The higher Overwaard *boezem* is a polder that is under water and has been used to store water since 1760. In the current situation, the water level can fluctuate between 0.40 metres below Amsterdam Ordnance Datum to 0.90 metres above it, a difference of 1.50 metres. The excess water is pumped into the Lek. In the Nederwaard, the high *boezem* is no longer part of the polder-*boezem* system. The water levels here can vary between 1.20 metres below Amsterdam Ordnance Datum to 0.20 metres above it, but these water levels are determined by the needs of reed growers. The water from the low Nederwaard *boezem* is pumped into the pond, where the water level is higher than that of the Lek at low water. The water can then be discharged into the river via the sluice.

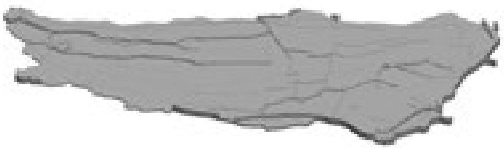
Apart from the low and high *boezems*, many of the mills that used to pump the water between the *boezems* have been preserved. The mills have been restored to working condition and they are used to demonstrate how the water levels in the reed beds are regulated. However, their capacity is not required to keep the Alblasserwaard dry.

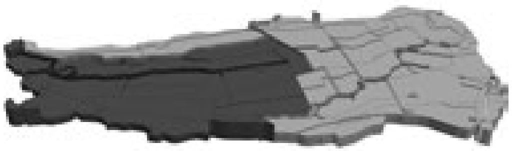
The dike of the Lek is at delta height and is a typical example of a dike that has been raised in height and reinforced several times, causing the spatial relationship between the dike houses and the river to become increasingly obscure.



5 km

5 km





▲▲
Polders of the polder complex of the Alblasserwaard

▲
Two drainage areas of the polder complex Alblasserwaard: the Neder- and Overwaard.
A part (light grey) is discharging its water from the Giessen, the *vliet* and the Achterwaterschap onto the lower *boezem*. The other part (dark grey) discharges its water onto the other lower *boezem*.

◄
Topographical map 1920 and 2009 of polder complex Alblasserwaard

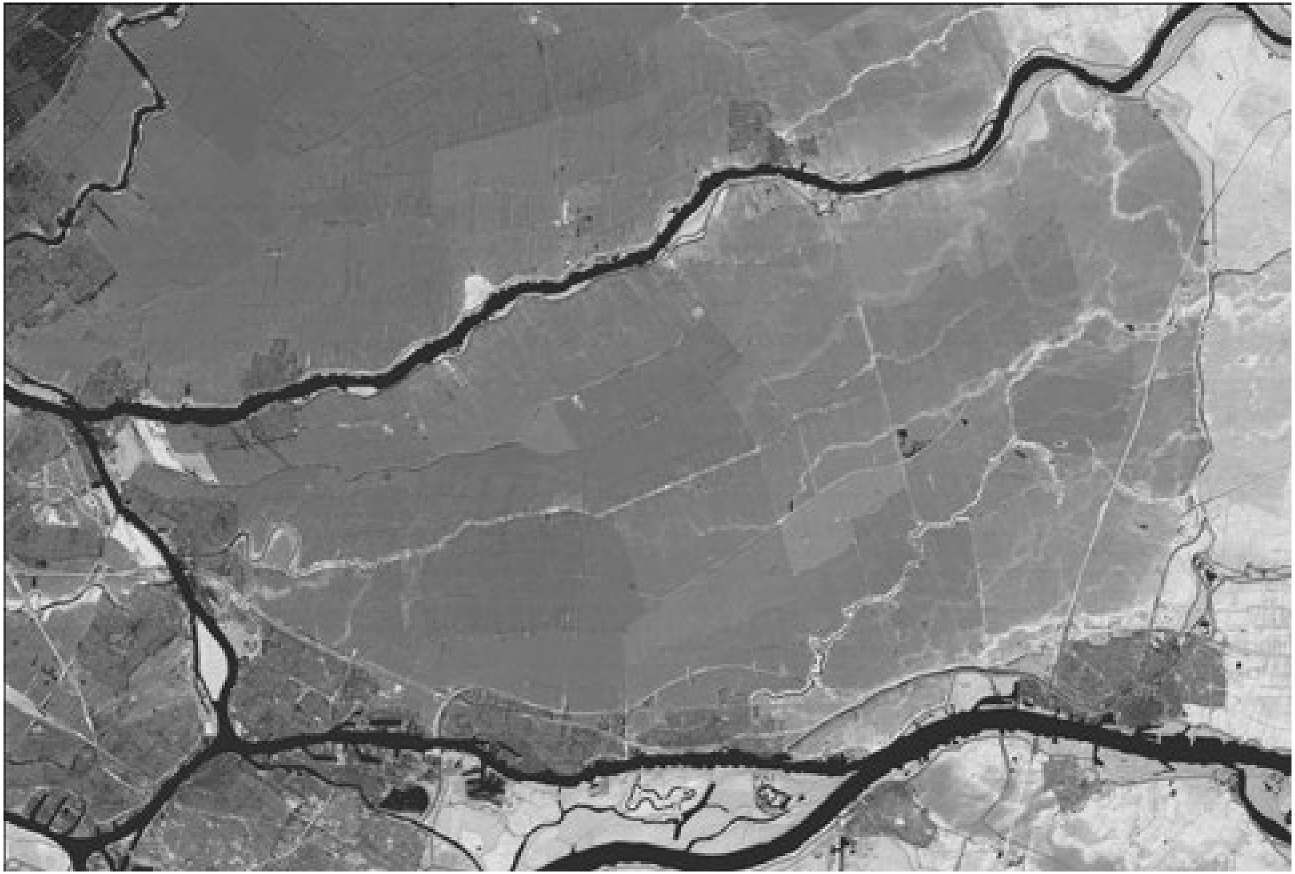
Pattern

The shape of all the peat polders is that of a typical elongated river polder, with the pattern of ditches at right angles to the river. Generally speaking, in a spatial sense the waard-drainage system (a waard is an interfluvial area between winter dikes) developed from a collection of separate, small water-management entities that drained straight into the river into a waard-polder complex with the central main axis that reversed the drainage flow in the direction of the new axis. In the Alblasserwaard there are two excavated low *boezems*, connected to the dammed-up peat rivers the Alblas and Giessen, an example of such a central main axis. The rivers were dammed up in 1280, and could then be used as a *boezem*, and later as interlinking *boezems*. At right angles to the interlinking *boezem* watercourses extend into the polder, each of them leading to a polder mill (in most cases replaced by a pumping station that is sometimes no more than a small cabinet). The interlinking *boezem* and the watercourses are elevated in the landscape.

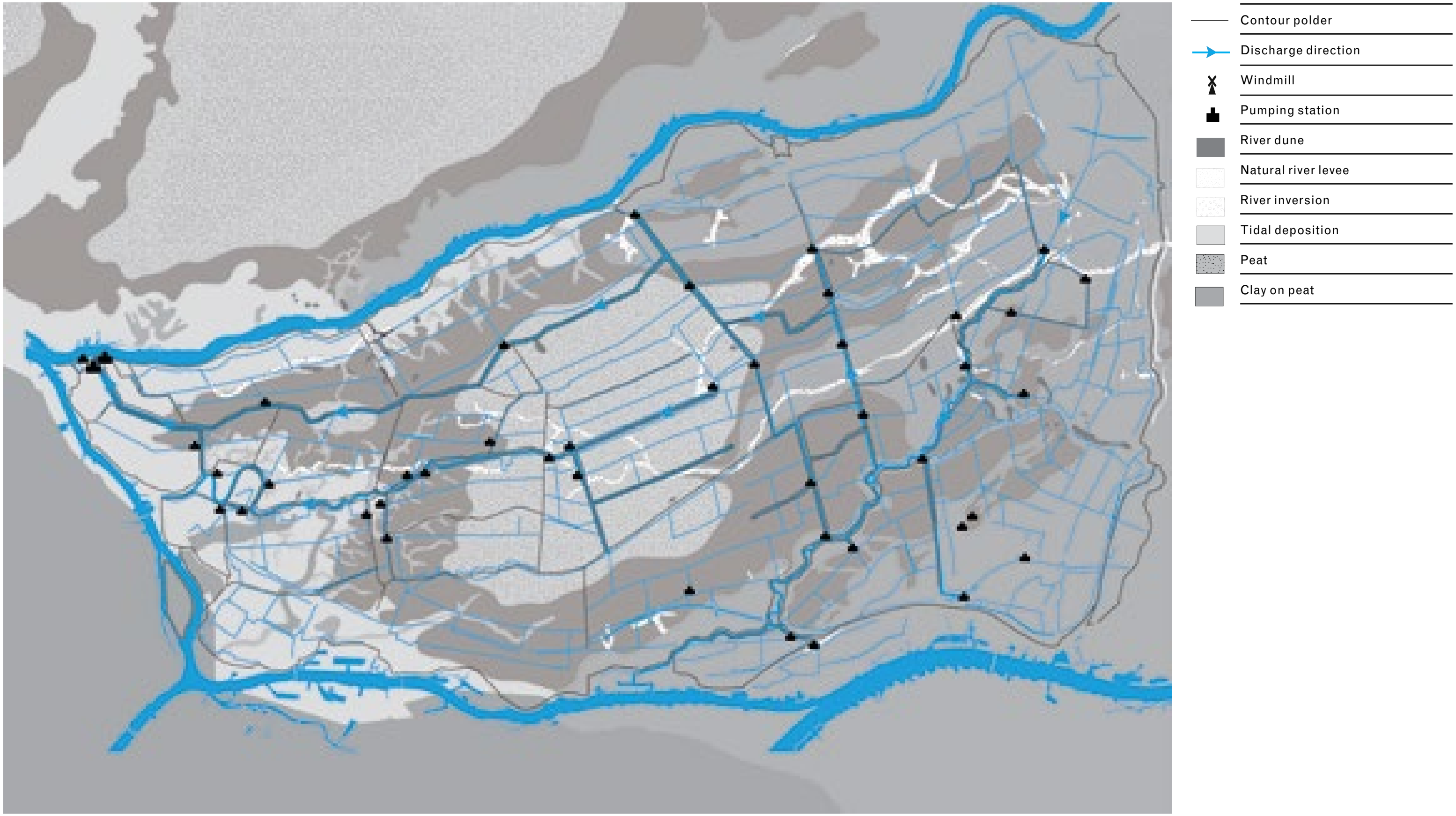
Waterworks

In 1740 it became necessary to pump the water from one *boezem* (now the low *boezem*) into a higher *boezem* (a storage *boezem*), thereby reducing dependence on water levels in the Lek for discharging water. Nineteen mills were constructed – sixteen of them in adjacent rows – for the purpose of pumping water from the two lower *boezems* into the two higher *boezems*. The mill complex has been preserved, and has been inscribed on UNESCO's World Heritage List as an impressive water monument.

The Regional Water Authority De Overwaard introduced the first steam pumping station in the 19th century to replace the existing polder mills. This was followed by many other small pumping stations spread throughout the polder. This first drainage stage still exists, although it has become less visible. Today, two large electric pumping station carry out the second drainage stage, from the interlinking *boezem* to the pond, followed by the third stage of the sluice. The water has to be pumped up from polder-water level to the millpond, amounting to a difference in elevation of some 4.50 metres on average. The water level in the Lek is approximately 0.5 metres below that of the pond so that, ideally, the water can be discharged via the drainage sluice into the river – with a current maximum water level of 3.00 metres at high water, and 2.00 metres at low water. The substantial difference in elevation between the polder and river water is due not only to the settlement of the peat but also to rising sea levels, among other things. Due to the rising sea level, seawater flows further up-river at high tide, raising the water level in the rivers.

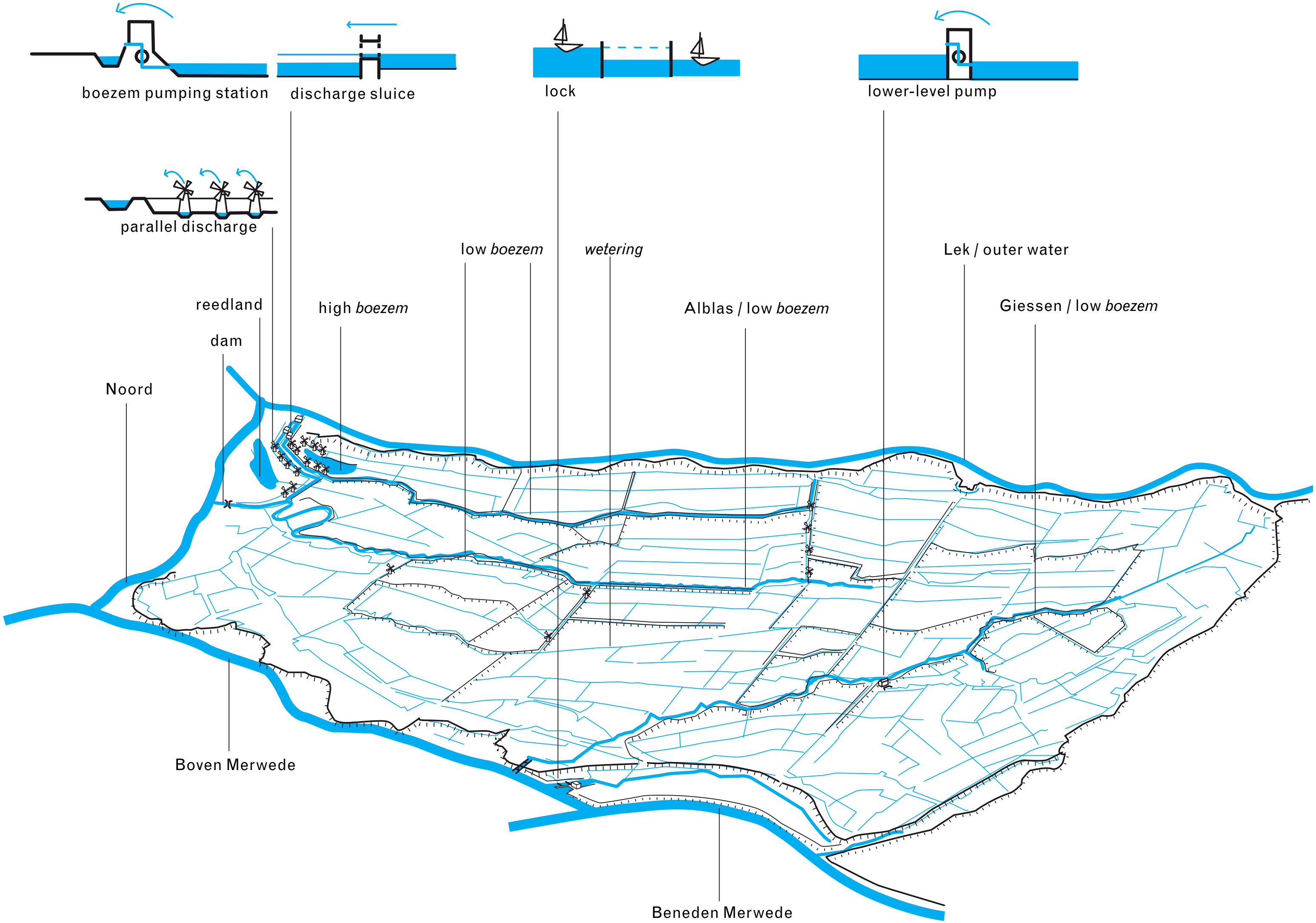


Altitude map of Alblasserwaard

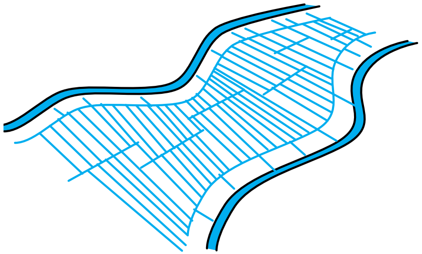


Water pattern and discharge direction of polder complex Alblasserwaard projected on the natural landscape

Technical water elements of polder complex Alblasserwaard

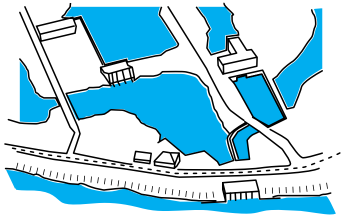


Water pattern
form: strips



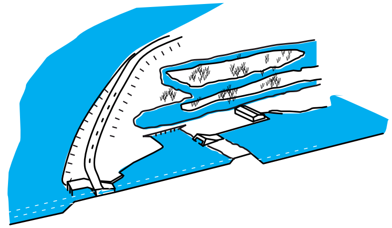
The peat polders in the rivers region are all typically elongated, whereby several plots which, in principle, used to discharge one by one into the river, now discharge into the *wetering* further inland. The dense pattern of ditches is at right angles to the river; the *weteringen* run parallel to the river.

Discharge sluice and pond
movement: falling and still water
form: enclosed, moving waterwork; framed body of water



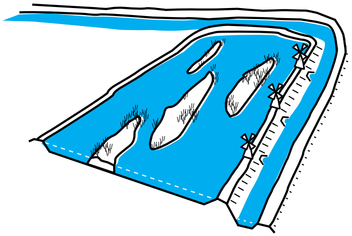
The discharge sluice and ponds are the third step in the drainage sequence of the polder complex. The combined sluice and *boezem* pumping station is set into the dike; the watercourse is not visible. The walls of the kolken, large water basins that can accommodate water levels higher than those in the high *boezem* and the Lek, are made of metal sheet piling.

***Boezem* pumping station**
movement: from low to high
form: enclosed waterwork



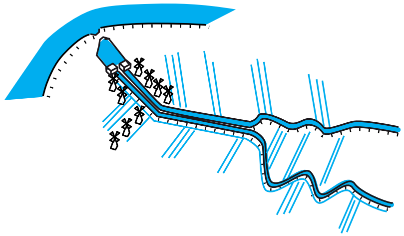
Two large pumping stations, very different in style and design, are situated at the head of the axis of the adjacent low *boezems*. The electric pumping stations took over the work of the lines of mills and 'mediate' between the various water levels, each within its own polder system.

High *boezem*
movement: still or mechanically flowing
form: reflective body of water



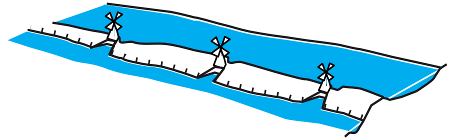
The high *boezem* is a body of water in a large diked area in the Overwaard. It covers an area of several hectares and is used for temporary water storage. The water level in the *boezem* can fluctuate by as much as 1.50 metres.

Low *boezem*
movement: still and mechanically flowing
form: elevated line of water



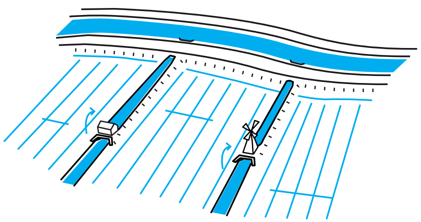
There are two low *boezems* in the Alblasserwaard. They consist of dammed-up, meandering peat rivers and excavated watercourses that link up to form a network. In the definition given earlier in this book, a low *boezem* is an interlinking *boezem*.

Line of mills
movement: from low to high
form: visible, moving waterwork



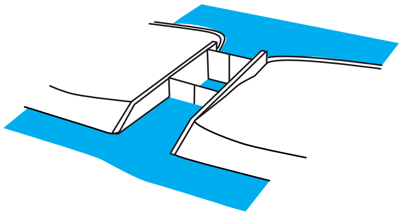
In the Alblasserwaard, two pumping station consisting of lines of mills operating in parallel have been preserved. Together, these mills pump the water from the interlinking *boezem* to *boezem* level, which is up to 1.5 metres higher. Both pumping stations have lines of 8 mills, which can be turned to face the wind.

Polder pumping station with water-course
movement: still, and from high to low
form: visible, moving or enclosed waterwork and line of water



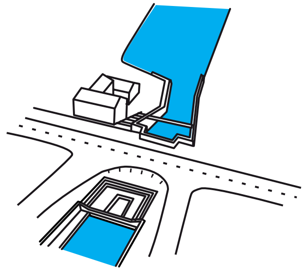
Dozens of small pumping stations connect polders and water-level areas to the interlinking *boezem*. Most of the installations – windmills or electric mills – are positioned on a branch of the interlinking *boezem*, at the deepest point of the polder, in the middle of the polder.

Lock
movement: rising and falling
form: reflective, walled-in enclosed body of water/waterwork



The low *boezem* of the Nederwaard is connected to the low *boezem* of the Overwaard by a lock near Alblasserdam. There is a 30cm difference in elevation between the two interlinking *boezems*. The lock is only navigable by small boats.

Dam
movement: still
form: enclosed/framed water surface



The Alblas and Giessen peat rivers were dammed-up in the 13th century because the land had subsided and there was a risk that the river would flow into the polder. The site of the dam has always been an important meeting place in towns and cities. It was a transfer point for agricultural produce and other goods.

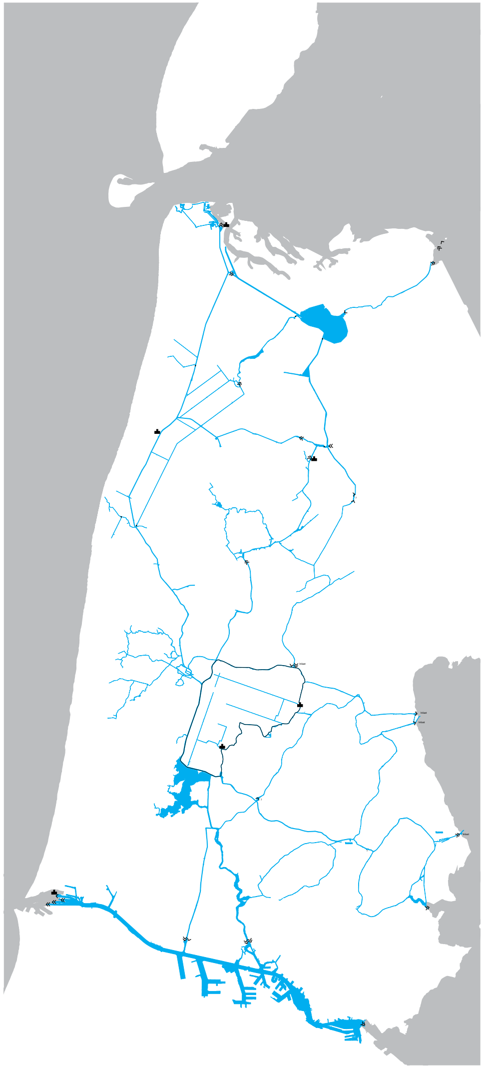
Schermer

- lake-bed polder: on average 3.6 metres below Amsterdam Ordnance Datum
- area: 4,550 hectares
- strip parcelization, unique design due to inner *boezem* on a 1.5 metre elevation, now used for water storage
- drained in 1635
- bed/soil: mainly clay, with peat around the edges
- Regional Water Authority: Hollands Noorderkwartier
- *boezem* area: Schermer *boezem*
- originally 14 water-level areas/compartiments, today 2 polder compartimentss
- drainage sequence: ditch – *tocht* – pumping station – ring canal/*boezem* – sea or IJsselmeer;
  until 1925: ditch – *tocht* – multistage mills – inner *boezem* – stepped multistage mill configuration with mill ponds (kolken) – ring canal – via the IJ or the Zuiderzee

The Schermer was one of the last large naturally eroded lakes in Noord Holland, which was drained between 1633 and 1636. Before the Schermer lake could be drained, two discharge canals had to be dug across Noord-Holland, one running south towards the IJ and the other running north, linking up to the Grote Sloot, through the Zijpe, and into the Zuiderzee. This guaranteed the drainage of the Schermer and also of the surrounding polders that previously discharged into the Schermer lake.

The process of draining the lake started with the construction of a dike and the excavation of a ring canal. On the north side, the dike builders connected the dike to the existing, strongly meandering Huygendijk. The ring dike on the north-east side partly consists of a peat dike with a gradual slope. Towards the south, the dike contains more clay and therefore has a considerably steeper profile. At the beginning of the 19th century, the ring canal on the south and west sides was widened and extended to become the intensively used Noordhollandsch Kanaal.

On the east side of the Schermer lake, areas of old land were enclosed within the ring dike. The first upper mill was built on this residual peatland in order to drain the lake. The first 'middle mills' were built slightly further on, on as low a level as possible. The scoop wheels of these mills could be easily lowered. Initially, the middle mills assisted the drainage carried out by the upper mills. When the water in the lake had been drained to the level of the middle mills, the first inner *boezem* was excavated



◀◀ Aerial photo of the lake-bed polder Schermer

◀ Discharge system of the lake-bed polder Schermer

- Flow direction
- Contour polder
- Weir
- Lock
- Polder pumping station
- *Boezem* water
- Outer water


Omval
zp-4.15
gzp-4.25
Het
De
-3.8
180 ha
zp-4.30
115 ha
Stompetoren
31 ha
42 ha
70 ha
002 - 24
054 - 14
90 ha
380 ha
zp-4.40
440 ha
zp-4.30
-3.7
De
47 ha
Matten
125 ha
-3.5
Polder de
1 km

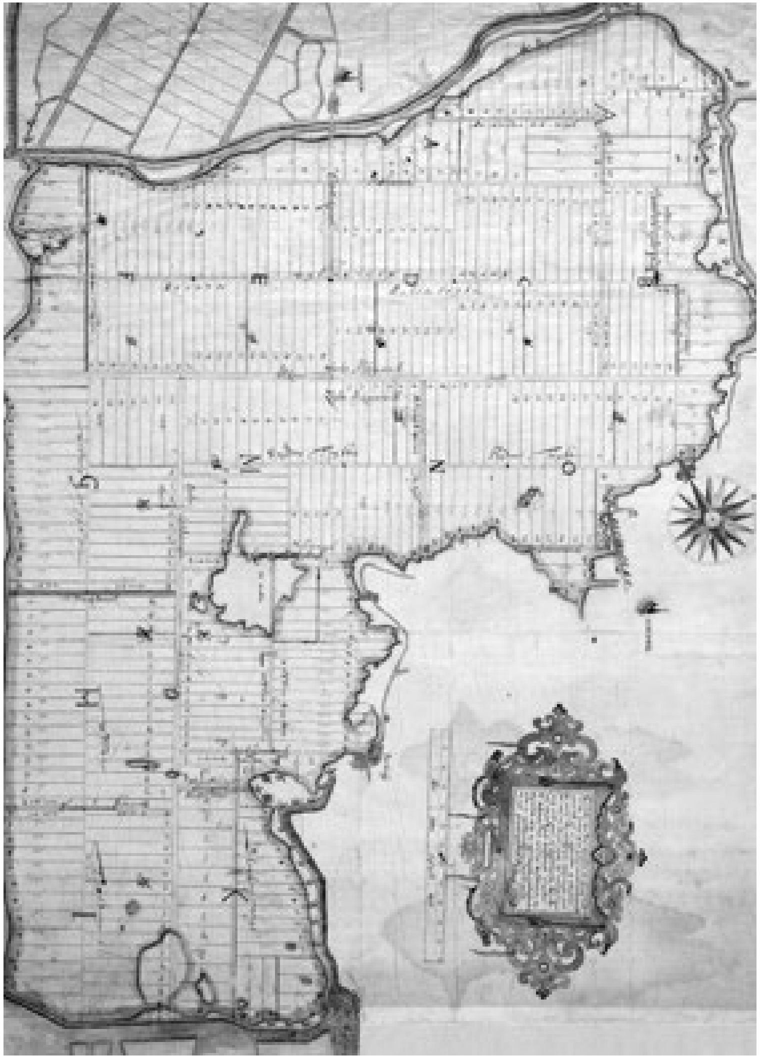
Detail *Waterstaatskaart* (map of water system) of the lake-bed polder Schermer

and connected to the mills. Until 1925, the Schermer had three groups of mills, with a total of more than thirty mills. The multi-stage configuration was on three or four levels; the water was pumped into a kolk before being pumped to the next stage/level. Each stage/level consisted of a group of mills that eventually discharged into the ring canal. Each of the fourteen polder sections was drained by one mill, which pumped the water into the inner *boezem*.

The lake-bed was carefully assessed when the Schermer was designed. The bed had a varied relief, and consequently a very specific and ingenious water system was developed for the Schermer. An inner *boezem* was created on a higher level than the polder bottom. This *boezem* consisted of the Noordervaart, Zuidervaart and Laanvaart, with a number of smaller branches perpendicular to it, to which the polder mills were connected. As a result of this system, the polder mills – the first stage in the drainage process – came to be situated in the middle of the polder. With the introduction of the polder mills, small differences in water levels in the polder could be accommodated, and the polder was divided into fourteen compartiments. This intensive form of water management made it possible to set the required water level in the polder and optimise conditions for specific land uses.

Discharge and dike form

In the present-day situation, the water is pumped into the ring canal by two large pumping stations on the east side of the Schermer. From the ring canal, which was made when the lake-bed polder was created the water is carried northwards and southwards via the discharge canals. To the south, the polder water passes through a sluice in the Amsterdam-Rhine canal (formerly the IJ) at Zaandam, and from there it is discharged into the sea. To the north, the *boezem* drains into the IJsselmeer (formerly the Zuiderzee). The profile of the dikes has changed little over the years.



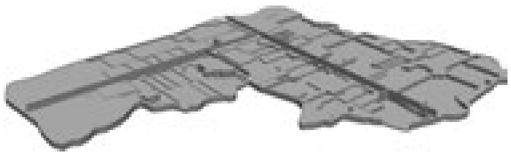
N

1 km


Heerhugowaard
ALKMAAR
Gemeente Schermer
De Schermer
Polder A
Polder C
Polder E
Polder L
Polder I
Polder K
Polder O
polder
De Rijp

N

1 km



Drawing of *peilvakken*, divided in two polder sections

Map 1635 en topographical map 2003 of the lake-bed polder Schermer

Pattern

Due to the construction of an elevated inner *boezem* when the polder was created, the Schermer has the most technically interesting, hierarchically ordered drainage pattern of all the lake-bed polders discussed thus far. The drainage sequence led from the ditch – sometimes via a *tocht* – to the polder mill, and from there to the inner *boezem* via a multistage mill configuration. The water was carried from the inner *boezem* to the ring canal via a series of stepped mills and millponds. The ponds and inner *boezem* could hold large volumes of water in the interim, which meant that the polder's water system was extremely flexible.

Today the water pattern is largely unchanged, but the water circulation has changed considerably. The inner *boezem* no longer fulfils a crucial role as a second stage in the drainage sequence. The water is pumped from the ditch directly into the ring canal via the *tocht*. The number of polder sections has been reduced from fourteen to two, and several polder mills have consequently become obsolete. Several water-level areas are connected to the same *tocht* by means of weirs and/or run via culverts under the interlinking *boezem*. The original compartments between the dikes of the inner *boezem* and the lines of mills no longer reflect the organisational water-management boundaries in the polder. However, the transformed inner *boezems* and multistage mill configurations remain as a spatial feature of the polder.

The waterworks

At the beginning of the 20th century, the three groups of mills were replaced by powerful electric pumps. Like the mills on the residual peatland, the three pumping stations were connected to the inner *boezems*. These installations from the 1920s are protected as listed buildings, as are several surviving mills that have been restored to their former glory.

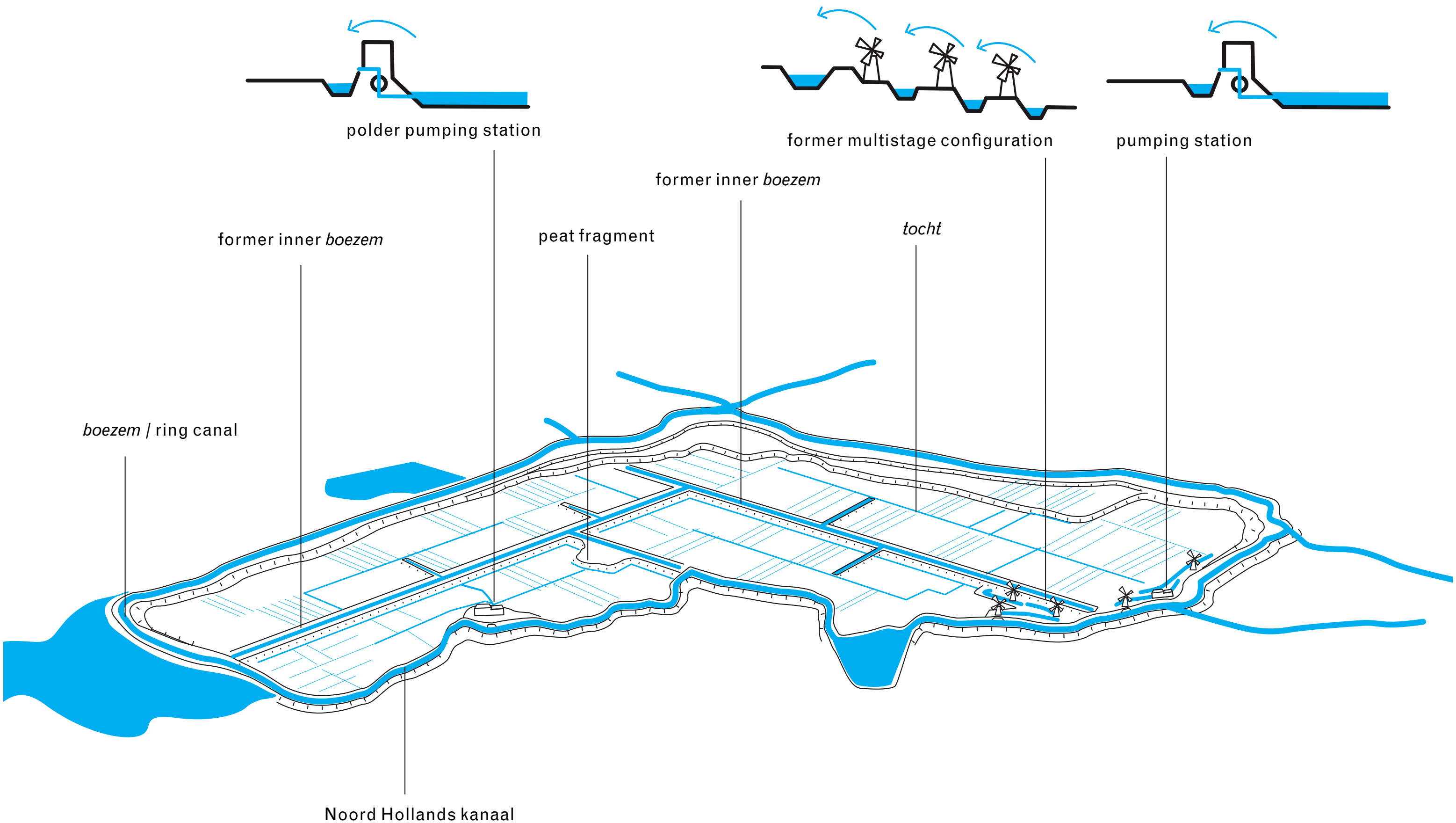
Since 1998, drainage in the polder has been carried out by two computerised electric pumping stations. They are no longer connected to the inner *boezem* but are an extension of the *tochten*, which are on the same level as most of the ditches. The mills that are still operating or have been restored, and the small pumping station, pump the water into the inner *boezem*. The water in the inner storage *boezem* can be used to irrigate the polder in the summer. Hence the inner *boezem* has a new function, namely as a water storage area. Many weirs and dams regulate the water levels in the unusually large number of water-level areas in the Schermer. The water ultimately flows into the *tochten*.

Altitude map of the lake-bed polder Schermer

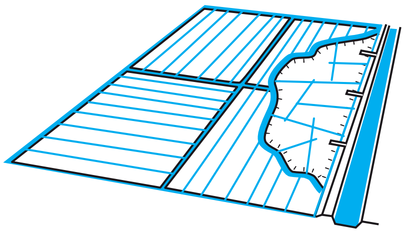
- Dike
- Contour polder
- Discharge direction
- Pumping station
- Dunes on clay or peat
- Old dunes
- Former lake
- Peat
- (Old) clay

Water pattern and discharge direction of the lake-bed polder Schermer projected on the natural landscape

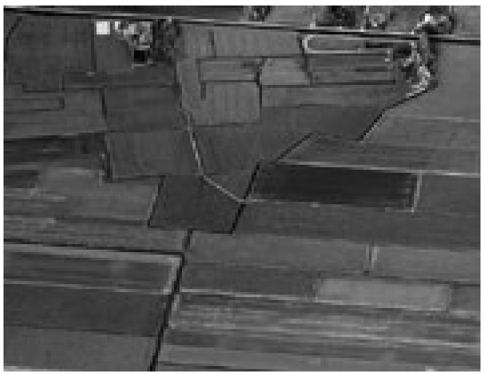
Technical water elements of the lake-bed polder Schermer



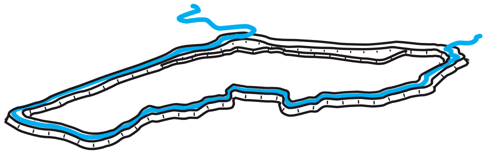
Water pattern with peatland fragment
form: block grid



The parcelization of the Schermer was based on a plot size that was functional at that time, namely 120 x 925 metres. The plots extend between a ditch running along the road, on the one hand, and the *tocht*, which collects the water. The plots are combined in blocks for drainage purposes.
Old fragments of peatland on higher ground appear as islands in the rationally parcelized landscape.

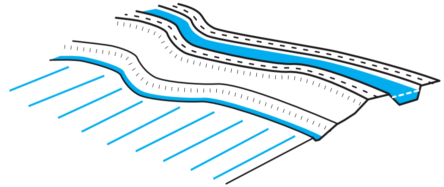


Ring canal - *boezem*
movement: still and mechanically flowing
form: elevated ring of water



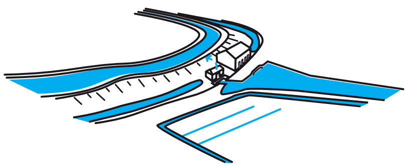
A characteristic feature of most lake-bed polders is an excavated ring dike with a canal (*vaart*), which demarcates the polder boundaries. The Schermer ring canal was not fully excavated; in the north, it incorporates an existing dike and the water behind it.

Ring dike
form: linear elevation



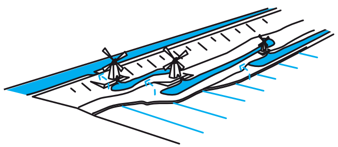
The ring dike varies in profile and shape according to differences in soil composition and its surrounding land. The section of the dike that was constructed in the lake has the typically steep profile of a clay dike. Where the dike was built on residual peatland, its slope is much less steep.

Pumping station
movement: from low to high
form: enclosed waterwork



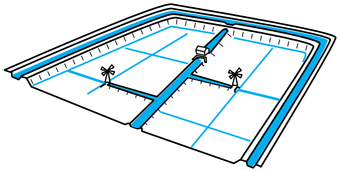
As in many other polders, the Schermer has several generations of pumping stations situated close together. The old pumping stations from the 1920s are connected to the inner *boezem*; the new pumping stations are connected to the *tochten* via a bypass.

Multistage mill configuration
movement: still, and from low to high
form: moving, visible, repeating waterwork and body of water



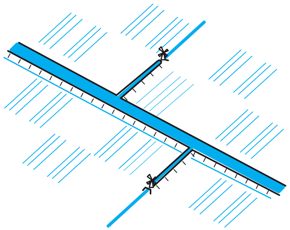
In recognition of their cultural and historical value, parts of the multi-level mill configurations, comprising mills and millponds (kolken), have been restored and partly reinstated. The mill configurations were sited on residual peatland and created an imposing ensemble. The locations of the mills and the end of inner *boezem* were not aligned in spatial terms; a water bypass was required here too.

Inner *boezem*
movement: still
form: elevated line of water

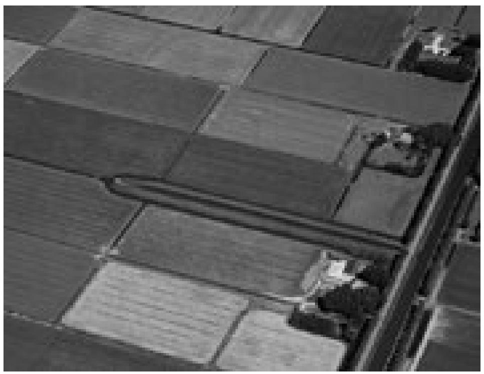


Two large *vaarten* 6.5 km and 7.5 km are situated in the middle of the polder, perpendicular to each other and elevated 1.5 metres above ground level. For many years these served as the first stage in the drainage sequence of the polder. Today they function as water storage areas. The latent monumentality of the inner *boezems* is reinforced by fragmentary rows of trees.

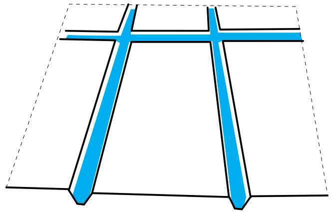
Mill with watercourse
movement: still, and from low to high
form: moving, visible, waterwork and line of water



The watercourses are situated at a level 1.5 metres above the polder floor and connect to the water of the inner *boezem* at right angles. Here and there you can still see a mill or small electric pumping station, supplying water to the inner *boezem* that is used for water storage. The dikes of the water-courses, like the inner *boezem* itself, divide the polder into spatial compartments.

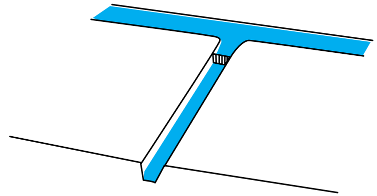


Ditch
movement: still and mechanically flowing
form: narrow line of water

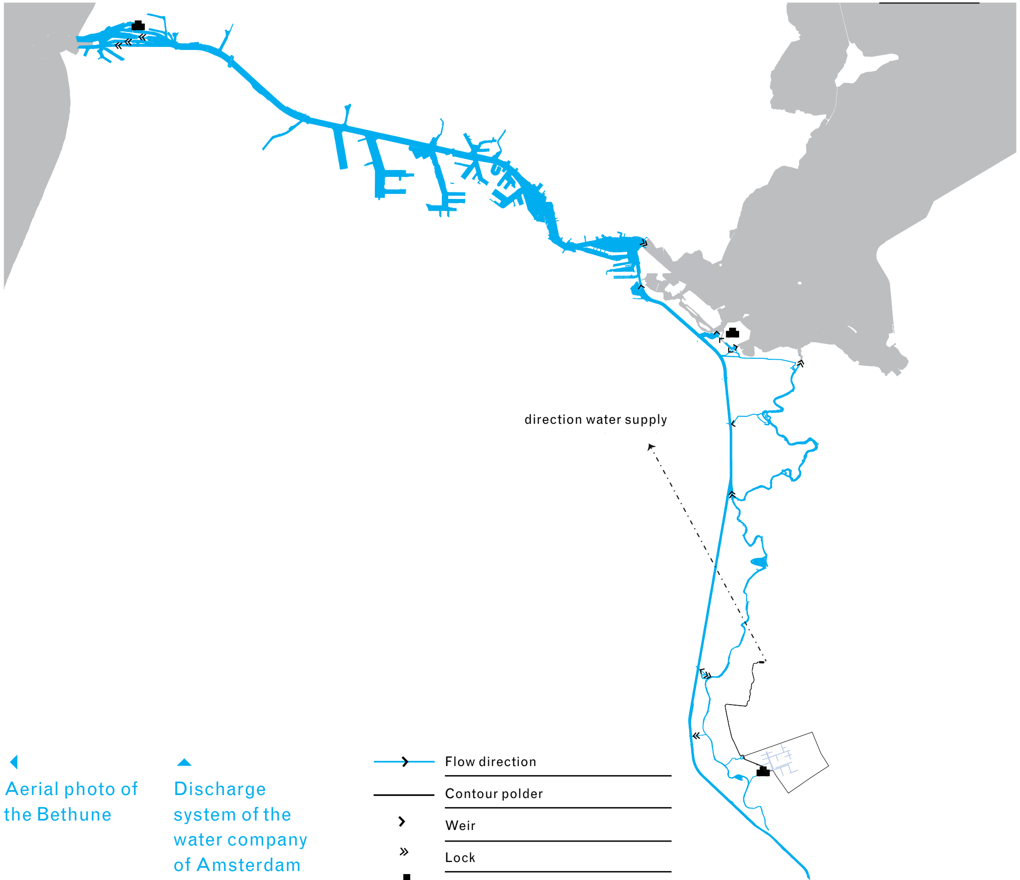


The water in the ditches of a lake-bed polder is usually low-lying, at least 0.50 metres below ground level. The steep sides are made possible by the sticky quality of the clay. Because the ditches are deep and narrow, the water in them can hardly be seen i.e. experienced from the polder bottom.

Weir
movement: blocking or falling
form: separating, small waterwork



Differences in the elevation of the polder floor can be regulated by means of a weir, both in ditches and wider watercourses. Since the Schermer was reclaimed, a large number of weirs have been placed in the ditches. The polder features a particularly finely meshed structural organisation of the water level.



Aerial photo of the Bethune

Discharge system of the water company of Amsterdam

Bethune Polder

- lake-bed polder: on average 2.50 metres below Amsterdam Ordnance Datum
- area: 540 hectares
- remarkably finely meshed water structure as a result of seepage water from the Utrecht Hill Ridge
- reclamation began in the 12th century, peat excavation from the 17th century, drained between 1881 and 1878
- soil: from peat moss to clay with peat and sand
- Regional Water Authority: Amstel, Gooi & Vecht
- *boezem* area: Vecht
- 1 designated-water-level area
- drainage sequence until 1970: ditch – *tocht* – pumping station – side canal to the Vecht, *boezem* – Amsterdam-Rhine canal – the IJsselmeer, open water; since 1970, due to the construction of the new installation by the Waterleidingbedrijf Amsterdam, water is extracted purely for drinking-water supply and is transported to Amsterdam partly through open and underground watercourses.


PLAN VAN BEDIJKING TOT DROOGMAKING

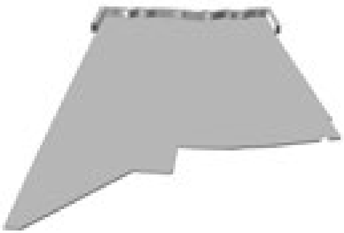
1 km


Ruimzicht
Tienhoven
Gemeente Maarssen
Polder Maar.
Nijenrode
Oudaen
Voorn Fort
Gd
De Venderij
(Natuurreservaat)
Polder
Bethune
Ruimzicht
Oud-Maar
Polder
Nijenrode
N402
Sl
Gansenhoef
Vecht
Zuiveringsinst
Br en Sl
MAARSSEN
Lageweg

1 km

The Bethune polder was created by merging the Tienhoven and Maarsseveense lakes. From an agricultural perspective, the polder is a failure because of the persistent seepage from the Utrecht Hill Ridge. Partly because the seepage water is of a high quality, the polder is used to supply drinking-water and the possibility of giving most of the polder over to nature is being considered.

The polder was part of the inundation zone of the New Dutch Water Line and has been inundated a number of times, the last time being in 1940. Fort Tienhoven marks the south-west corner of the polder, and Fort Maarsseveen the south-east corner.[7]



◂ Map 1858 and topographical map 2009 of the Bethunepolder

▴ Drawing of peilvak of the Bethunepolder

Discharge and dike form

The polder extends in a north-south direction, hemmed in by peat-stripped land, the artificial-lake landscape. From west to east, the polder lies between peat polders in which the ditch pattern is parallel to the dike. The lake-bed polder is surrounded by a ring canal, consisting of older navigable canals (*vaarten*) linked by several sections of canal dug when the polder was reclaimed. The polder is pumped by a pumping station, not into the *boezem* system, but into a separate drinking-water system consisting of open watercourses and pipes (see drainage map). In the past, excess water from the lake-bed polder was discharged into a side canal of the Vecht. The peat river is connected to the Amsterdam-Rhine Canal at several places, including a canal that runs through Breukelen. The Amstelland *boezem*, the Vecht, the Amsterdam-Rhine Canal and the North Sea Canal are directly connected to the sea, and discharge excess water into the North Sea via the sluice or the pumping station at IJmuiden.

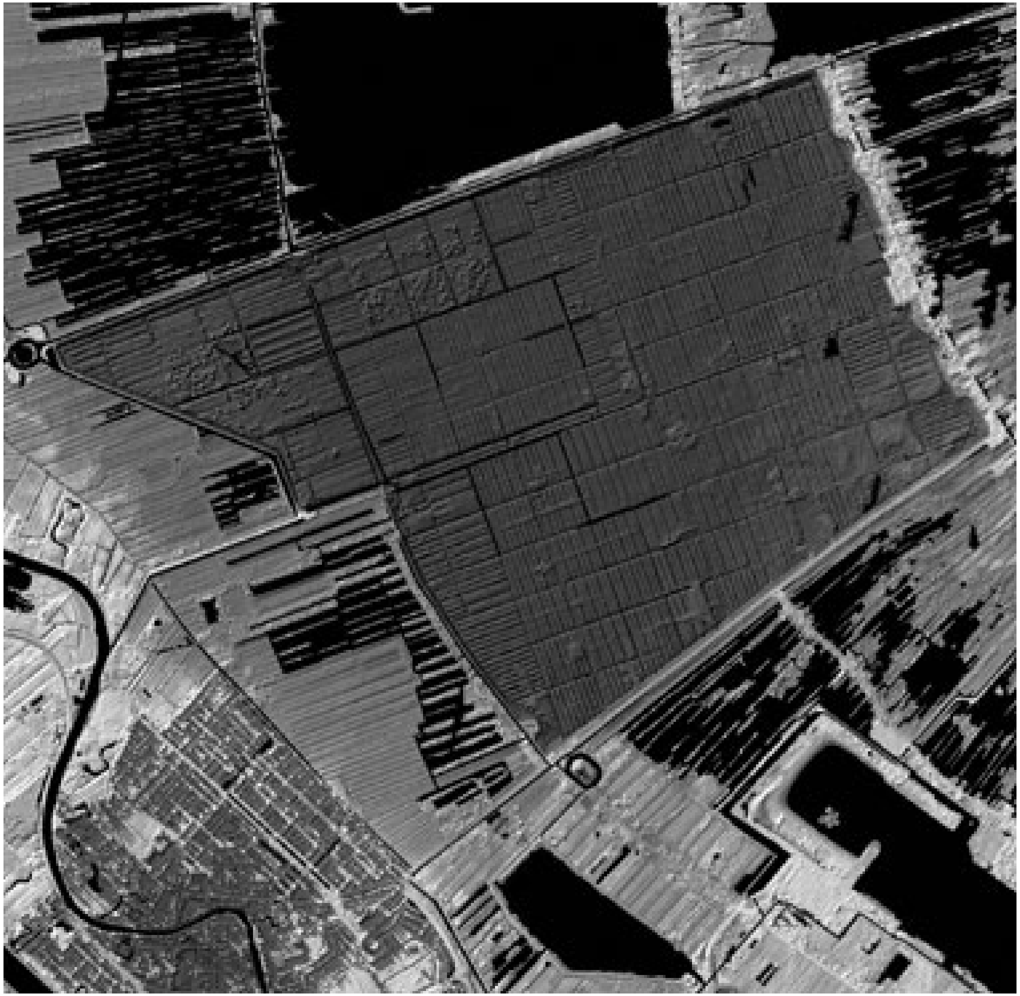
The external boundaries of the lake-bed polder are demarcated by existing dikes and embankments in the landscape. The polder is bordered by an old peat dike along the Tienhoven Canal, extended to the fort, and by a peat dike along the Maarsseveen Canal on the south side. On the east side, the polder is bordered by residual peatland on which the villages of Tienhoven and Oud-Maarsseveen are sited, as with Maarsseveen on the west side. It was difficult to reclaim the polder, as a result of constant seepage from the Utrecht Hill Ridge. The water level in the ditches did not fall until after 1930, when the Amsterdam drinking-water company began to extract water to supply Amsterdam.

Pattern

Despite the fact that the polder has been stripped of peat, the pattern of peatland reclamation remained. This is probably owing to the fact that, due to continuing settlement, the original ditch system became increasingly important for storing water and therefore became a fixed part of the topography.[8] The parcelization is based on a reclamation grid of approximately 200 x 200 metres. The polder blocks comprise four plots of approximately 50 x 200 metres. In some places the ditches make a quarter-turn within a block, producing interesting water patterns. The ditch pattern has changed considerably over time. Some of the ditches have fallen dry, and in other sections ditches have been added, because the soil lets in seepage water there and the land had become waterlogged.

The difference in soil structure between the north-western and south-eastern parts of the polder is visible through the land use. In the north-west, the soil is much wetter; the seepage water rises to the surface. Some of these wet sites are marked by groups of trees. The south-eastern part of the polder is more suited to agricultural use, since the soil is more sandy and therefore more stable.

Due to the low elevation of the Tienhoven section of the polder in relation to the Maarsseveen section – with the two



Dike

Discharge direction

Pumping station

Natural river levee

Peat

Clay (on peat)

◂ Altitude map of the Bet-hunepolder

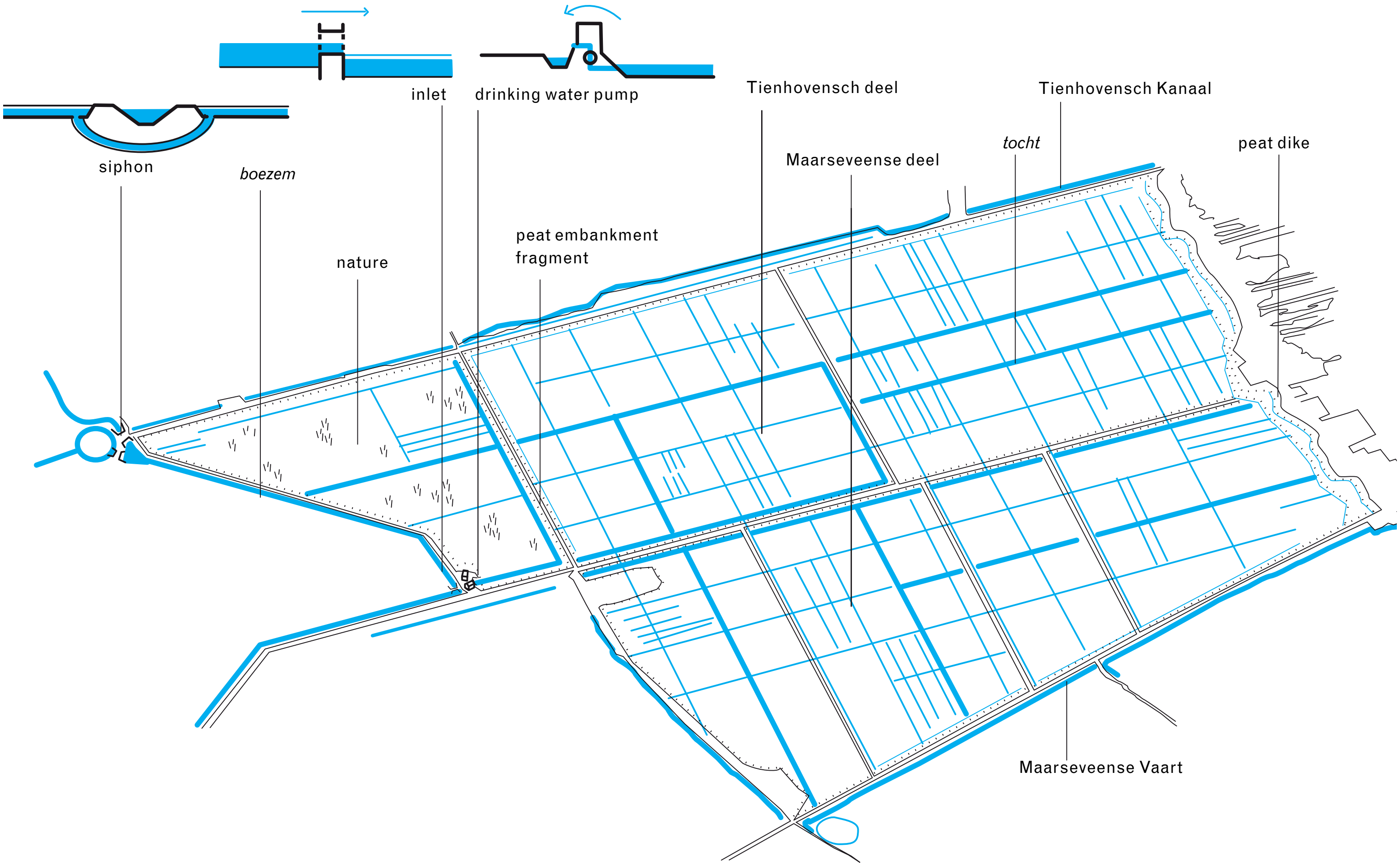
▸ Water pattern and discharge direction of Bethunepolder projected on the natural landscape

sections separated by the Middenweg – one main drainage channel was not sufficient, and a system of parallel watercourses had to be designed. The long *vaart* south of the Middenweg drains the southern part of the polder, and the shorter *vaart* north of the Middenweg drains the northern part of the polder. Settlement of the peat layer that is still present in the north-west of the polder has increased the differences in use and visibility between the two areas.

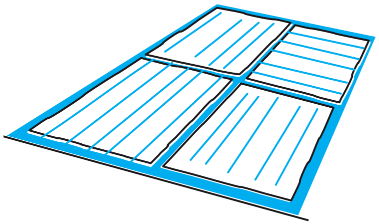
Waterworks

In 1858 a pumping station was constructed on the lowest level in the polder, near the seepage area in the north-western part, west of the peat embankment. In 1930 the Gemeente Waterleidingen Amsterdam built a new electric pumping station, which was replaced in 1971 by a new, fully automated electric installation, which pumps away the water that is used for drinking water. The original installation on the Machinekade, a unique industrial monument, is no longer in use but can be deployed when necessary. When in use, it discharges water into the Vecht.

Technical water elements of the Bethunepolder

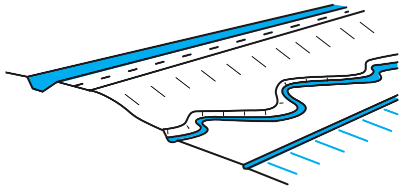


Water pattern
form: chessboard pattern



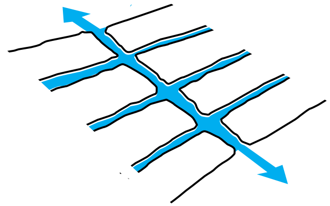
Long narrow plots of land combined into square blocks. The parallel ditches within a block always run in the same direction, although the direction in one block may be perpendicular to that of the ditches in another block. The ditches (*tochten*) between the blocks are wider than the ditches that separate the plots. The density and length of the ditches in a block vary according to its soil composition.

Peat dike
form: broad elevated ridge/line



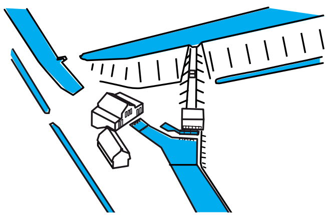
The former artificial lake was not diked and then drained, but could be enclosed within the existing peat dikes and residual peatland. This is particularly visible on the northern edge of the polder, where the old peatland gently slopes towards the bed of the polder.

Tochten
movement: still and mechanically flowing
form: broad line of water



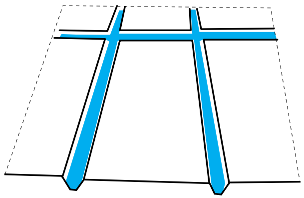
The water from the ditches flows along the wider ditches between the plots and into the *tochten* alongside the road in the central axis of the polder. There is not a great difference in width between the plot ditches and *tochten*, but they do differ in length. As in the rest of the polder, the water level in the *tocht* is high.

Pumping station
movement: from low to high
form: concealed waterwork



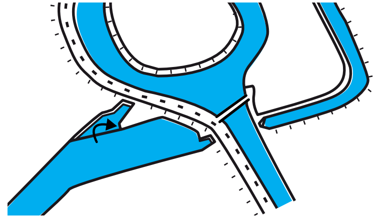
In the Bethune polder, the most important waterwork is actually the pumping station that extracts water from the polder for drinking water. The water is carried from the station via a pressure pipe. The old installation is only used when there is excess precipitation, and it discharges the water into the Vecht.

Ditch
movement: still and mechanically flowing
form: narrow line of water



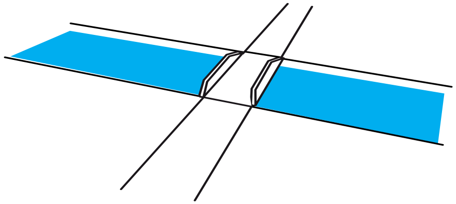
In the polder there are ditches of two different sizes. The ditches are sited within a block, and the wider ditches between the blocks carry the water to the *tochten*. The lake-bed polder is not suitable for farming due to constant seepage and poor soil quality, and only parts of it can be used for grassland. High water levels are therefore maintained in the ditches in order to prevent further subsidence.

Island and siphon
form: land encircled by water and enclosed, invisible water conduit



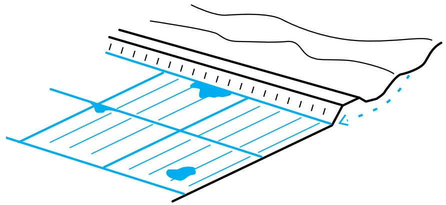
Fort Tienhoven, part of the New Holland Water Line, is sited on the outer edge of the polder. The moat around the fort is part of the small section of ring canal on the east side of the lake-bed polder. The channel for the drinking water, with a different water level, runs under the moat by means of a siphon, a cylindrical construction with a lowered central section that connects two watercourses.

Bridge
form: open, repeating waterwork, land link over water, accentuating the water line



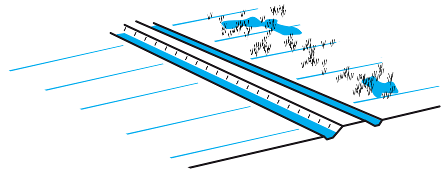
Simple concrete bridges with a low wall span the *tocht*. As a result of this intervention, the attention is drawn slightly more to the *tocht* than to the plot ditches, which are just as wide, and the horizontality of the landscape is reinforced.

Seepage – water point
movement: rising
form: changeable water surface

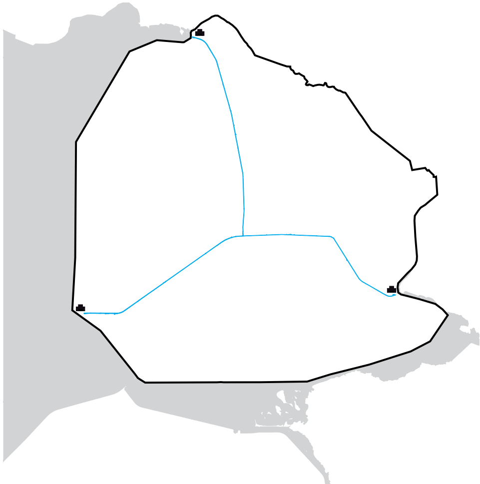


Due to constant seepage, due to sand in the soil and the low elevation of the polder in relation to the Utrecht Hill Ridge, the lake-bed polder is used mainly as pastureland and a drinking-water extraction area. A new trend is to combine drinking-water extraction with nature development.

Peat embankment – fragment
form: elevated ridge/line



There is an old peat embankment in the north-west, in the middle of the polder. The embankment appears to be the polder boundary, but it is not. The heaviest seepage occurs to the west of the embankment. The embankment separates the part of the polder designated as a nature reserve from the part of the polder that is still used for farming.



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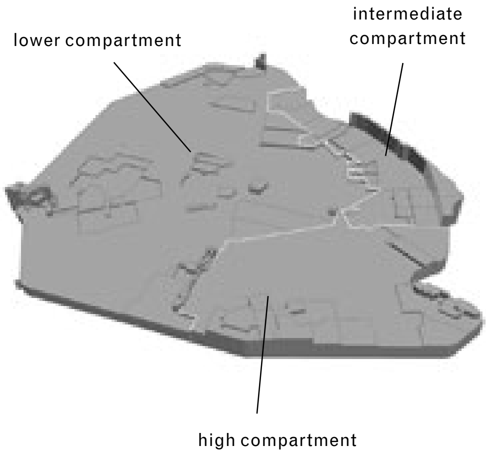
Discharge system of the Noordoostpolder



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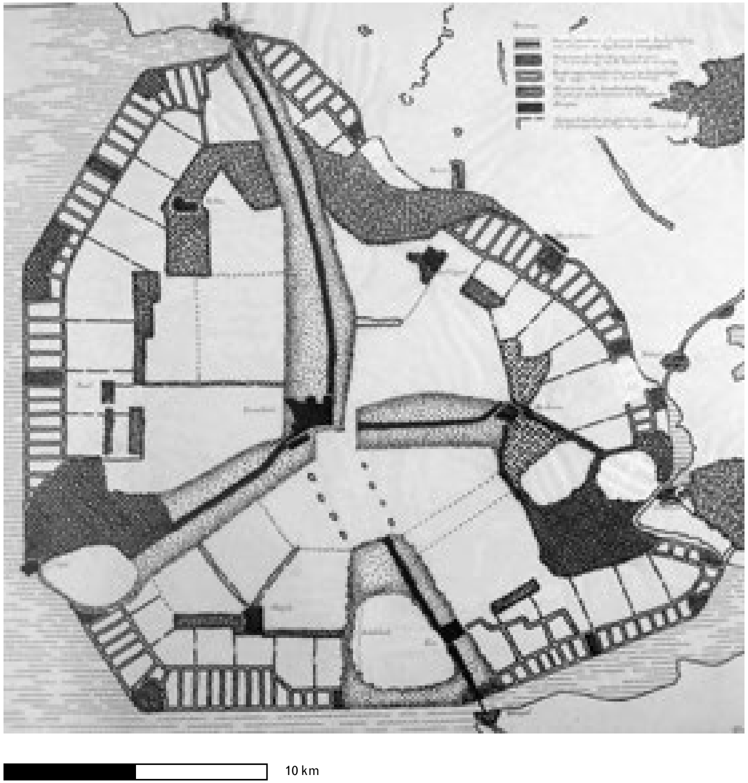
Drawing of *peilvakken* and the three polder sections of the Noordoostpolder

Noordoost polder

- modern lake-bed polder: on average 4.50 metres below Amsterdam Ordnance Datum, rising to 0 metres below Amsterdam Ordnance Datum in the east.
- area: 55,00 hectares
- modern polder with water-transport network, with broad lines of water
- drained between 1936 and 1942
- soil: mainly sea clay with residual peat and boulder clay
- Regional Water Authority: Zuiderzeeland
- *boezem* area: IJsselmeer
- three polder compartiments: the high, intermediate and low compartiments, with several water-level areas within
- each compartiment
drainage sequence in a polder section: invisible drainage pipes at a depth of up to 1.20 metres - ditch - *tocht* - *vaart* - pumping station - IJsselmeer, the open water



Landscape design 1943 and topographical map 2003 of the Noordoostpolder

The Noordoostpolder was the first of the IJsselmeer polders to be drained. This took place ten years after the completion of the Afsluitdijk causeway. It was the first polder in the Netherlands of which the development was not approached purely from the perspective of land engineering, but as an integrated project, combining land development, urban planning and landscape architecture.

The polder was drained by 1942, but it took until at least 1960 to complete the definite structure. Soil amelioration was necessary in at least two-thirds of the polder, in order to make the land suitable for agricultural uses. In some places, the land was designated for forestry, in particular the boulder-clay areas and sandy soils around Urk, to the north-east of Bant and to the north-east of Kraggenburg. The villages in the polder were built in a ring around the central town of Emmeloord. Woodlands were planted around the villages, to act as a windbreak on the one hand, and also to provide areas that could be used for recreational purposes.

The definitive plan drew on many interim plans that had been rejected for a variety of reasons. An example is the Pouderoyen plan of 1943, with intensive planting that emphasised the main water structure of the polder while at the same time attempting to structure the polder on a human scale, also through planting. The idea of structuring the polder as a vaarpolder, meaning that the farms could be reached by boat, was implemented, but was and remains scarcely utilised because an extensive road network was built at the same time.

Discharge and dike form

Water is discharged from the polder via three large pumping stations situated at the ends of the large *vaarten*. Due to its elevation, the lake-bed polder does not have a ring canal but discharges its water directly into the IJsselmeer. Only the Smeenge pumping station discharges into the Kadoelermeer, a lake that is connected to the IJsselmeer (open water). The polder slopes gradually downward from 0 metres Amsterdam Ordnance Datum on the former coast of the Zuiderzee to 5.00 metres below Amsterdam Ordnance Datum in the west. The lake-bed polder is bordered by high dikes on the north, west and south sides. These dikes, which prevent flooding from the open water, are part of the primary water defences and must comply with extremely stringent safety standards. The IJsselmeer side of the dikes have a very robust construction, because north-westerly winds can cause high swells.

Pattern

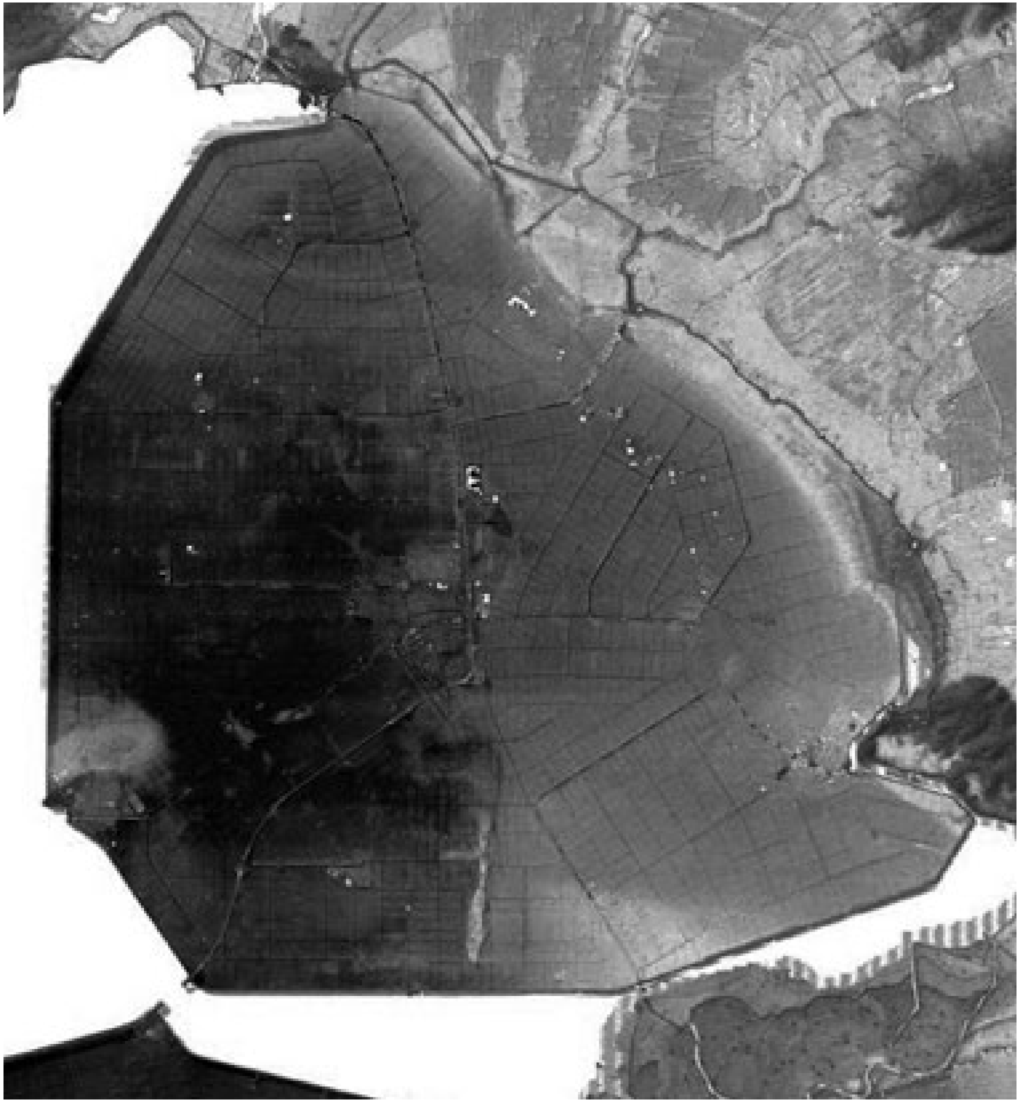
The land in this lake-bed polder is divided into blocks. The axis system of main canals divides the surface of the polder into three segments. The point at which the three canals meet is in the middle of the polder, near the town of Emmeloord. The two former islands, Schokland and Urk, are situated on a higher level with respect to the former lake bed, and interrupt the polder's regular discharge pattern. Towards the higher edges of the polder and the sandy soils, extra water needs to be continually let in to infiltrate the soil where there is a risk of dehydration due to water seeping away.

The polder has two compartiments (see the white line on the map showing the designated-water-level areas). The average water level in the lowest-lying compartiment is 5.7 metres below Amsterdam Ordnance Datum. Within each compartiment there are many designated-water-level areas, where the water levels are regulated in accordance with the irregular relief of the polder bed. The designated-water-level areas are connected by weirs and small pumping stations for secondary drainage.

Waterworks

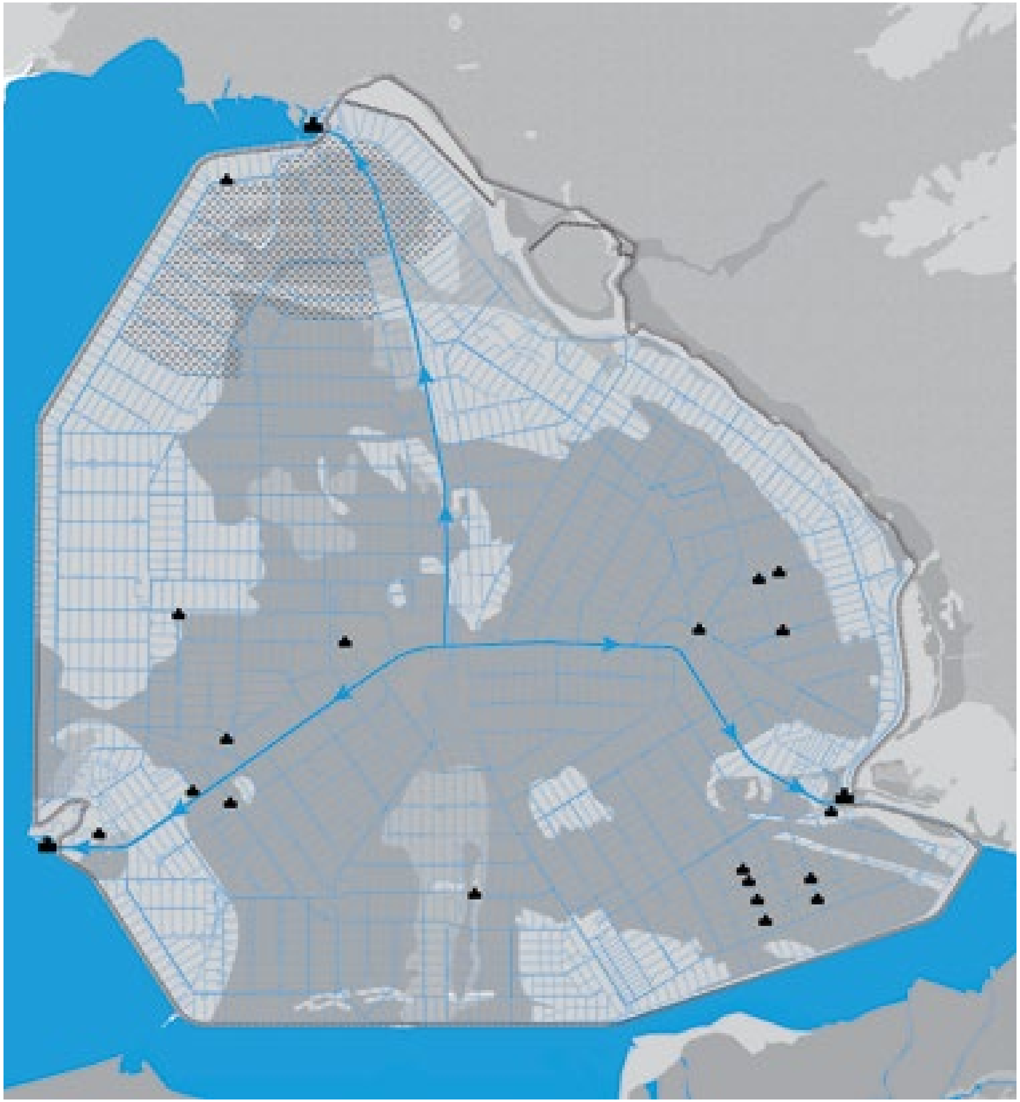
The three pumping stations that initially drained the polder are still in use, although they have since been modernised. The Vissering pumping station near Urk, together with the Buma station near Lemmer, drains the low-lying section. In 1946, the steam engines of the Vissering station were replaced by diesel engines. Around the turn of the century, these were replaced with fully automated gas engines in the same building. The building is in a visible location on the dike. There is a lock next to each of the pumping stations.

There are four navigable locks in the Noordoostpolder, emphasising the importance of shipping in the polder. The Zwolse Vaart (canal) has two locks. The Markenesser lock in the polder bridges a small difference in elevation. The Zwolse Vaart ends at the Voorstersluis lock, next to the Smeenge pumping station. Here the difference in elevation between the polder water and the Kadoelermeer lake is no less than 5 metres.



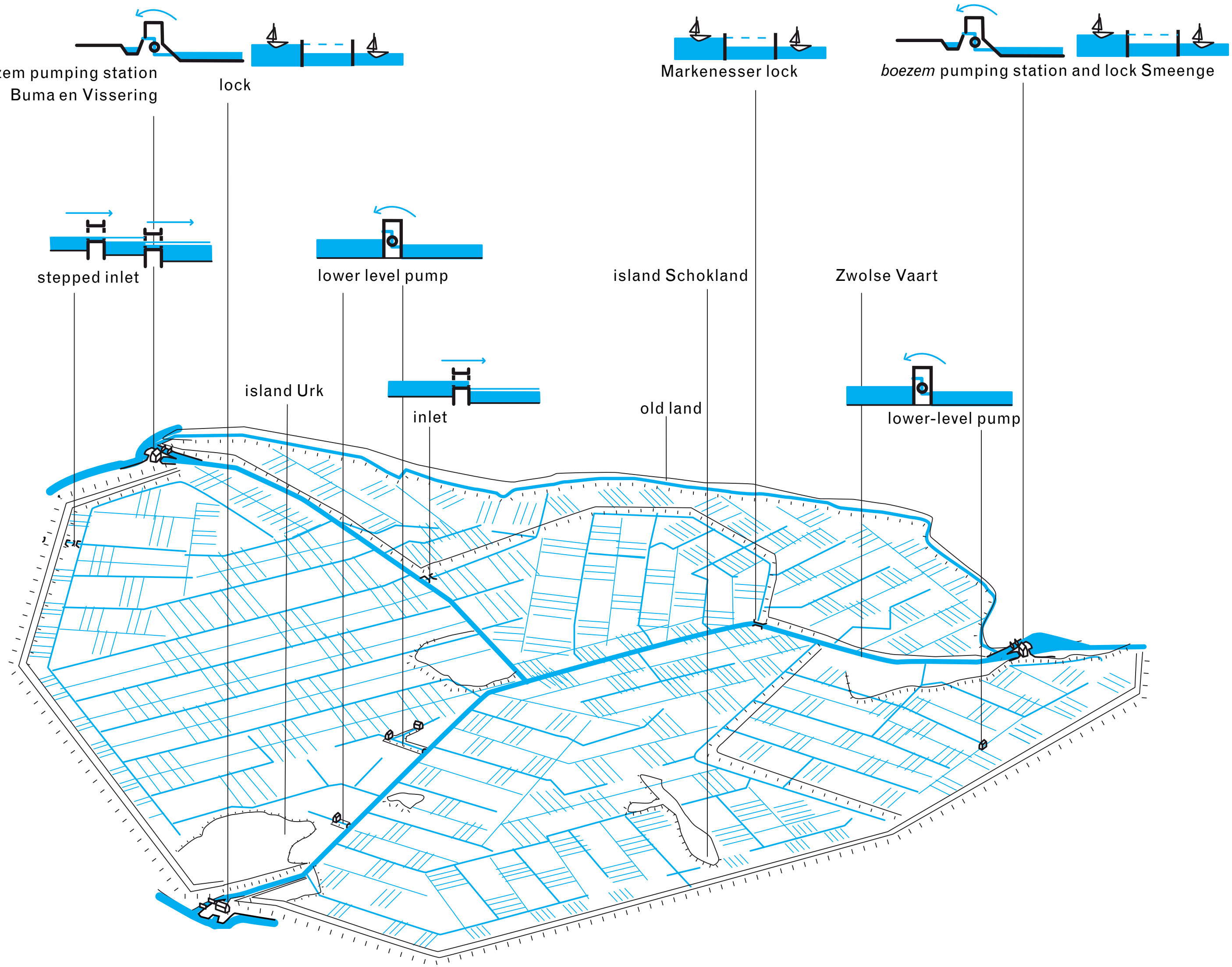
Altitude map of the Noord-oostpolder

Inlets are situated mainly on the edge of the polder. Due to the considerable difference in elevation on the edge of the polder, the inlets are clearly visible, and designed as stepped watercourses and waterfalls.

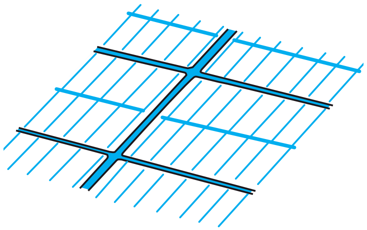


◀ Water pattern and discharge direction of the Noordoostpolder projected on the natural landscape

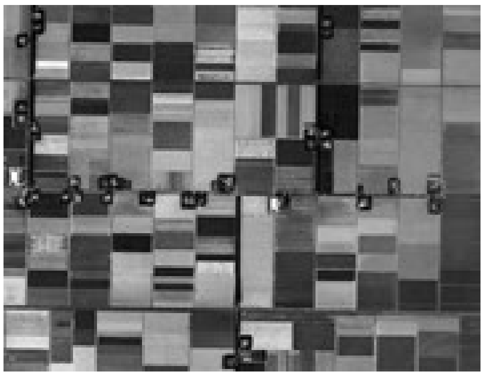
Technical and landscape architectonic water elements of the Noordoostpolder



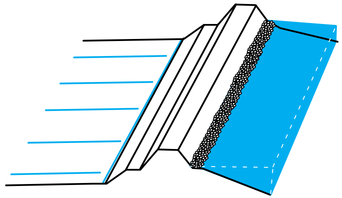
Water pattern
form: block parcelization



The standard plot of land is 300 x 800 metres. It was possible to create wide plots by laying underground drainage pipes in the middle of the plot, 1.20 metres below ground level. The ditches connect at to the *tochten* at both ends.

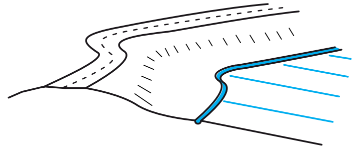


Sea dike
form: strong, robust elevated line



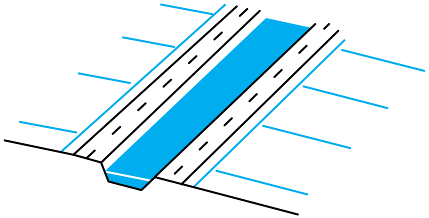
The average height of the sea dike is 5 metres above Amsterdam Ordnance Datum. The dike belongs to the primary line of water defences, because it is adjacent to open water (IJsselmeer). The outer slope has a robust, partly stony structure. The inside of the dike is covered with grass and is equipped with a ditch at its foot to collect any water seeping through the dike.

Old land
form: elevated, rolling plane



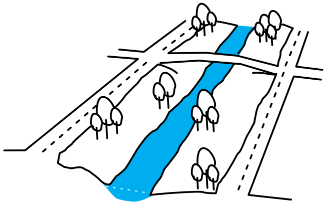
Unlike the Flevopolder, the Noordoostpolder is not separated from the old land by water; rather, it is connected to it by a low dike. There is not a great deal of difference between the ground level of the old land and that of the lake-bed polder. Due to the specific soil composition at the edge, the layout (plot size and land use) is different from that in the rest of the polder.

Vaart (navigable canal)
movement: still and mechanically flowing
form: broad line of water



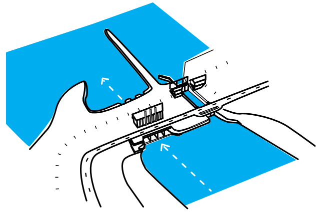
The main canals with locks are very wide – 30 metres – and could therefore certainly be described as monumental. They are suitable for shipping. Narrower canals (*tochten*) link up to the main canals at right angles, and these are also navigable. The main canals divide the surface of the polder into three areas of roughly the same size.

Canal (_singel_)
movement: still and mechanically flowing
form: open, accessible line of water with a park-like layout



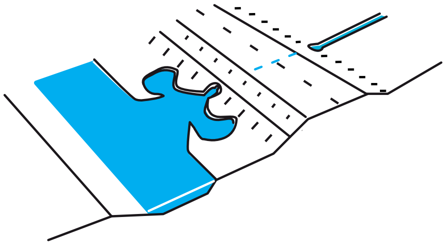
The profile of one of the many *tochten* changes when it reaches the built environment. The banks become less steep. The gentle slope is planted and landscaped in a park-like manner. Several bridges provide crossing points from one side to the other. The *singel* is not a barrier in the same way that a *tocht* is, but forms part of the public space in the urban environment instead.

Pumping station with navigable lock
movement: from low to high; falling and rising
form: enclosed, concealed waterwork and reflective, walled-in body of water/waterwork



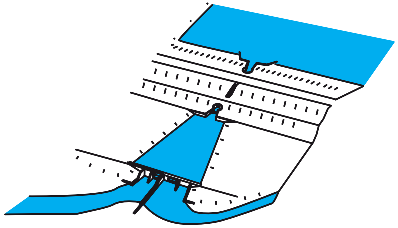
The pumping station and lock form an ensemble. The lock is sited in an extension of the *vaart*; the pumping station is also situated at the head of the *vaart*, but in a wider part of the *vaart* and therefore slightly displaced in relation to the axis. This means that the pumping station is not visible from the central sight line along the canal.

Inlet
movement: falling
form: open worked waterwork



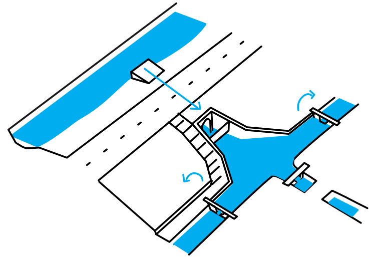
An inlet lets fresh water into the polder when there is a shortage of water, or to flush out the polder when the quality of the polder water lessens. An inlet usually consists of a culvert with a gate at one end to control the flow of water.

Stepped inlet
movement: falling
form: refined stepped watercourse, open worked waterwork



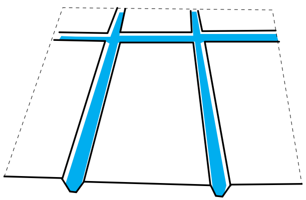
The Noordoostpolder has several inlets, mostly in the section close to the old land. The inlets let fresh water into the polder. These waterworks can be described as notable, due to their dimensions and elevation. The stepped flow of water accentuates the difference in elevation and renders the course of the water visible.

Stepped inlet
water movement: falling
form: refined stepped watercourse, open worked waterwork



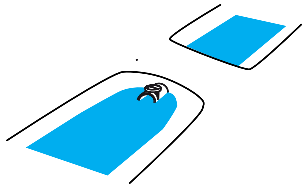
The Noordoostpolder has several inlets, mostly in the section close to the old land. The inlets let fresh water into the polder. These waterworks can be described as notable, due to their dimensions and elevation. The stepped flow of water accentuates the difference in elevation and renders the course of the water visible.

Ditch
movement: still and mechanically flowing
form: narrow, deep line of water



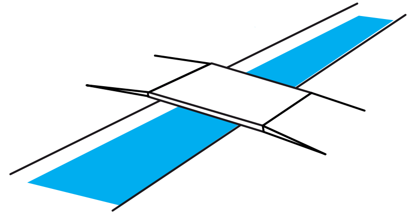
The ditches in the Noordoostpolder are deep and are fairly narrow in relation to the enormous area of land. Consequently, the water in the ditches is barely visible even in the polder. The ditches are mostly connected to the wider *tochten* via a culvert, or directly to a *vaart*.

Culvert and weir
movement: flowing and overflowing
form: enclosed and projecting waterwork



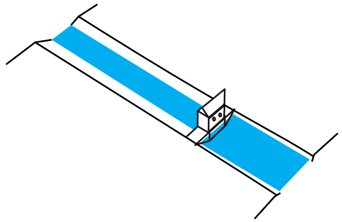
Ditches are connected by underground culverts, making the land accessible for agricultural machinery. Because a ditch usually narrows where there is a culvert, this is a useful place to regulate the flow of water by means of a weir.

Bridge
form: plane, link between plots of land



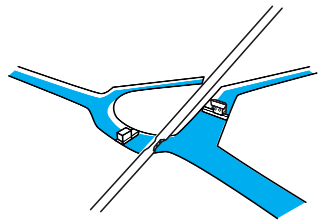
The flat bridges are utilitarian and clearly designed solely for agricultural purposes. They link two plots of land that are separated by a *tocht*. The bridge does not hinder or reduce the flow of water in the *tocht*.

Lower-level pump
movement: from low to high
form: enclosed, iconic waterwork



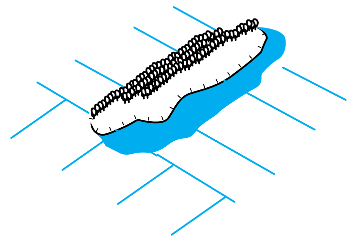
When a lake-bed polder is created, the aim is always to optimise the drainage system. Secondary drainage is necessary in a lake-bed polder, as in a peat polder, but as a result of the natural relief rather than subsidence. The lower-lying land is drained via a lower-level pump, a small mill or electric installation.

Waterplein **('water square')**
movement: inflowing and still
form: island and branching body of water



In the Noordoostpolder specific structures for secondary drainage were designed, commissioned by the Water Board. The location of the secondary pumps is significant; they mark a particularly deep point in the polder. The water from the lower-level pump is carried away via the *tochten* and *vaarten.*

Island – old land
form: elevated earthen mound



There were several islands in the former Zuiderzee. Two of them, Schokland and Urk, became part of the mainland as a result of reclamation. One of the methods used to prevent settlement is to let water into the islands. Another measure to prevent settlement is to keep the land waterlogged in the immediate surroundings of Schokland. Planting on the west side accentuates the elevated situation of the former island.

◂

Natural river levee in the polder

Zijdekade between Hei- and Boeicop polder

Westvaart dike, former multistage mills

IJsseldijk between Hekendorp and Oudewater

Peat dike polder the *2e Bedijking* in the Ronde Hoep

Dike along the Waver

Achterdijkse *wetering*

▸ Page 168

Hoofdvaart Haarlemmermeerpolder

Digging of a vaart in lake-bed polder

Berkelsche Zweth, branch of the *boezem*

Wetering in de Ronde Venen

Tussenboezem at Kinderdijk

Ditch in the Noordoostpolder

Conclusion

The Noordoostpolder is the youngest of the six polders discussed. This fact perhaps partly explains why, compared to the other polders, this large lake-bed polder has the most landscape-architectonically developed water elements. As explained above, when the IJsselmeer polders were laid out, the reclamation task was seen as an exercise in land development, urban-planning and landscape-planning. The pumping stations form an ensemble together with the sluices, a spatial conclusion at the end of the imposing water axes. The lower-level pumps are of a similar design to the main stations and also form an ensemble, situated as a pair at a water junction. The depth of the polder bed in this specific place is thus made visible. The landscape-architectonic articulation of the watercourse is particularly marked on the edge of the old, higher land and the new land. The stepped inlets have a sober design.

Because the water in villa architecture flows from a higher to a lower level, it is logical to suppose that water that flows downwards or falls can be designed more expressively than water that is pumped from a lower to a higher level. This assumption is refuted by examples such as the water sequence in the Alblasserwaard, where water from the low *boezem* is pumped up to the high *boezem* and discharge sluice via the Archimedes' screw. The system of many different *boezem* levels provides a large amount of water-storage capacity and its layered structure is very interesting from a spatial point of view. This is also evident from the example of the former inner *boezems* in the Schermer. Their elevated position lends monumentality to the water axes that can match that of the Grand Canal at Vaux-le-Vicomte.

The challenge of this book is to find and develop specific resources for the landscape-architectonic adaptation of the polder water by understanding the working and form of the polder-*boezem* system.

As discussed in this chapter, the water elements of the polders are of a purely civil engineering character, but they hold the possibility of being incorporated into a landscape-architectonic composition, thereby strengthening their significance and, perhaps, leading to a better understanding of their role in the vital water system.

Kockengen Polder (a peat polder) and Bethune Polder (a lake-bed polder) serve as examples that are illustrative in terms of finding starting points for a possible translation in terms of landscape architecture. The translation of the water elements is inspired by the landscape-architectonic repertoire of classical water gardens.

Kockengen Polder

Water parterre
The small Kockengen Polder, with its regular water pattern, evokes images of a water parterre. The decorative element, which emphasises the horizontality of the water as a reflective surface, is clearly visible, particularly from an elevated viewpoint. Digging extra ditches can articulate the water pattern more strongly. Adding a balcony around the mill on the higher level the water parterre will be visible.

Grand Canal
The Bijleveld and Heicop canals are substantial water elements that point to the horizon, and link the landscape and village at the *boezem* level. They also form the organisational axis of the area. One of the canals could perhaps be extended to form a Grand Canal. This could be achieved, for example, through planting along the line of water.

Belvedere
Given the high elevation of the embankment in relation to the polder surface, the embankment could serve as a belvedere, a structure designed to command wide views. The creation of contrived ‘windows’ in the existing vegetation and/or the widening of the embankment would encourage walkers to pause there and draw their attention to unique ‘polder snapshots’.

Nature experience
The characteristic jagged edges of the ditches in a peat polder can be accentuated by giving more space to vegetation from different phases in the transition from land to water, thereby reinforcing the image of a polder as part of rugged nature.

Windmill
The windmill is an icon of the Dutch lowlands and a symbol of the makeable land(scape). The windmill is a landmark and stands in an elevated position in the middle of the polder. Water is lifted from a lower to a higher level using wind force. In ancient times, air and water were among the concepts used to represent the various aspects of life.

Water steps
The working of a pumping station or mill is like that of water stairs in reverse. Power is needed to pump the water upwards, against the force of gravity. The sound of moving water symbolises life.

Water spout
The culverts in the polder are of a utilitarian design. They could be given a further design treatment, making the direction of flow visible. The sound of splashing or babbling water can accentuate differences in the water level.

Bethune Polder

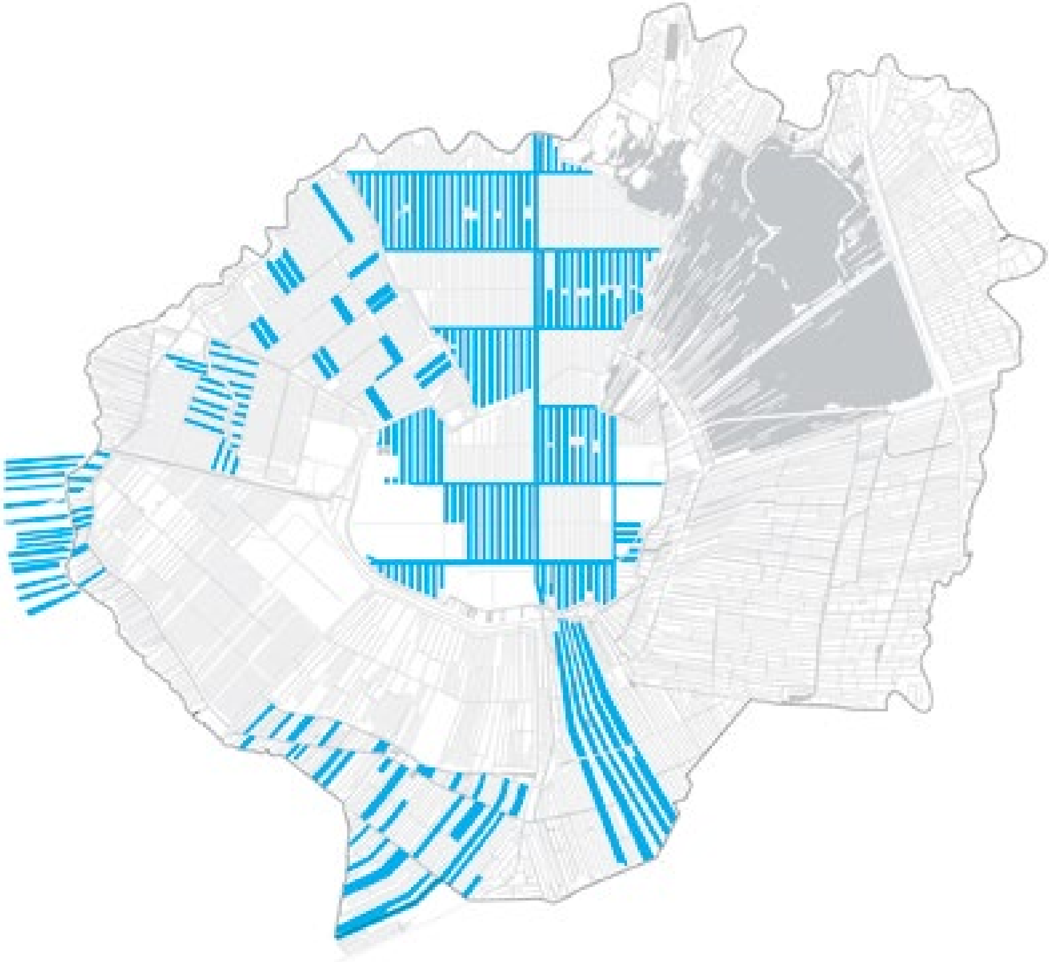
Water parterre
On the polder-floor of the Bethune Polder there is an interesting interplay involving the direction of the ditches of the land plots. The pattern is clearly visible from the edge of the polder, and displays an enormous number of variations on the simple theme of land and water in a squared grid.

Belvedere
The bridges with a low balustrade reinforce the long water axes in the polder. They could logically serve as a resting point or viewpoint.

Water axes
From the peat dikes along the north and south sides of the polder, the canals form impressive contiguous watercourses.

Spring
In the pumping station that is now partly concealed by the old one, the polder water is pumped into an interlinking *boezem*, like water stairs in reverse. From the *boezem* it is carried to Amsterdam via a drinking-water pipe. This particularly clean water rises up out of the ground, and thus comes from a different source than the water in other polders. In the landscape-architectonic treatment of the locus, the water bubbling to the surface could be further developed as a translation of a spring.

Water design



Water form experiment on plot measure in the polder complex of Ronde Venen

Landscape-architectonic adaptations of the polder landscape

In the previous chapter we discussed the form of polder water in three exemplary peat polders and three exemplary lake-bed polders. Various water forms and water-works were discussed from a site-specific perspective and made visible. This knowledge, and the knowledge of the technical functioning of the polder-*boezem* system are prerequisites for designing a landscape-architectonic water project in the polder or the *boezem* area.

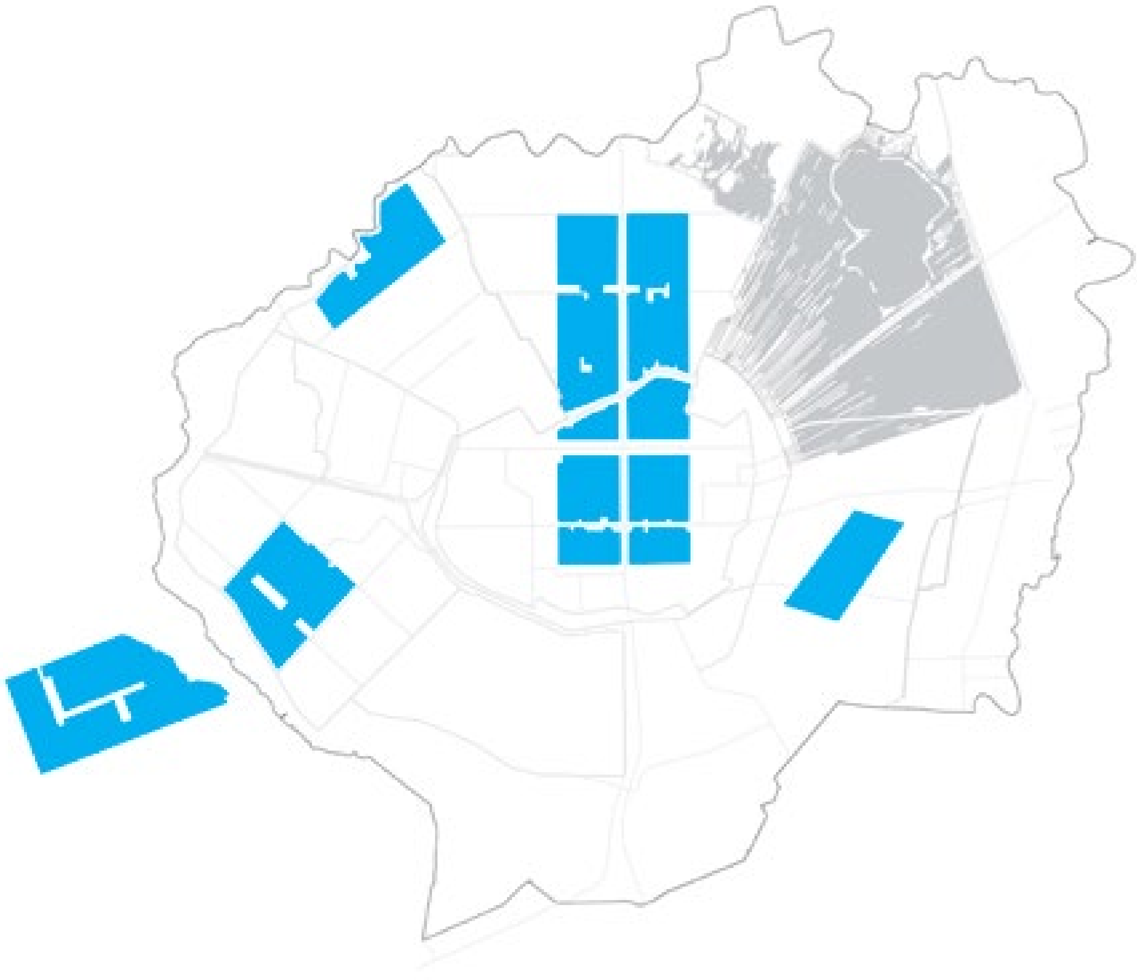
The polder analyses show that water-works are sited at the points where there are transitions between water levels or between designated-water-level areas, or at the point where the water leaves the polder.These elements are some of the crucial details of the polder-*boezem* system and present themselves as loci suitable for adaptation in terms of landscape architecture. They have the potential to become part of the spatial composition of new designs in the polder.

Apart from the spatial elements – the waterworks – it is above all the water pattern, i.e. the pattern of ditches and watercourses (*wetering*, *tocht*, *vaart*), which plays an important role in the polder landscape. In villa architecture, the transformation of the water pattern in the form of a water parterre forms part of the landscape-architectonic composition. The water pattern of the polder is functional and is inextricably linked to the drainage process. The water pattern in the polder – whether existing or transformed - should become a carrier of the landscape-architectonic composition as well.

Before discussing the four examples that are under construction or were recently completed, we will discuss design experiments in the Ronde Venen polder complex in order to illustrate possible water-pattern adaptations. By incorporating water storage in lake-bed polders and peat polders, water patterns are experimented with based on a number of basic formal concepts: the 'water plot' (waterkavel), body of water and line of water.

The main reason for choosing the examples is that they are situated in a polder landscape. Secondly, they work with the theme of a landscape architectural adaptation of the polder water. The projects are diverse in scale and function, and show the scope of future water design. The examples – the Eendragtspolder, Museum Belvédère, Wickelhof Park and the Onnerpolder pumping station – are evidence of the fact that cooperation between hydraulic engineers and designers is becoming increasingly necessary.

As in Chapter 4, the plans are outlined in relation to their natural landscape. This ensures that the relationship between the original landscape, the man-made landscape and the actual plan is visualised and explained. Six water elements have been selected in each project. Their technical function, position within the polder-*boezem* system, and significance for each project are discussed. The water elements are described using landscape-architectonic concepts, and we focus on the water pattern as the carrier of the composition.



Water form experiment with orthogonal water surfaces in the polder complex of Ronde Venen

Ronde Venen experiment

As part of the current plans for the Ronde Venen the possibility is being considered of inundating large parts of the lowest-lying polder in the complex – the Mijdrecht polder, 5.50 metres below Amsterdam Ordnance Datum - in order to provide the required water-storage capacity. If this lake-bed polder were completely inundated, the pattern of the water lines, the parcelization pattern and the furrows in the polder floor would be lost. In order to seek an alternative to this radical solution, experiments with the water pattern of the various polders are being carried out, as shown in the drawings below. Water volumes have been increased in order to reinforce the existing parcelization patterns, without changing current land use if possible.[1]

Water plot

The smallest unit in the polder is the polder plot. In the lake-bed polder, several plots are combined to form a polder block. Some of the plots in the block are excavated to a depth of 0.20 metres; the soil from this excavation is used to raise the height of the other plots in the block. The depth of the excavation is kept to a minimum so that the clay layer of the polder bed remains watertight, preventing groundwater from seeping through the polder floor. The water level can be raised, while it remains the same as in the old situation in terms of its relation to the ground level of the dry plots. In dry periods (nowadays even in spring or summer) water can be extracted from this storage area.

It is more difficult to construct a water reservoir in the peat polder of the polder complex because the water is just below ground level. This experiment is therefore not so much about creating a water storage facility but about creating an interesting new water landscape. Characteristic of the peat polder in the Ronde Venen is the elongated plot, giving an impression of boundlessness. In a densely populated country, this can be regarded as an important spatial quality. This effect of infinity is reinforced by inundating a number of plots, which also introduces reflective bodies of water into the landscape.

1 Bobbink , I., Rickert N. (2008). *Van veenbult tot ingenieuze watermachine.* Internal publication TU Delft

◂ Water form experiment by strengthening the water lines in the polder complex of Ronde Venen

Body of water

This experiment relates mainly to the parcelization pattern in the polder. In the transformation of the lake-bed polder, the typical 'grammar' of the polder [2] formed the starting point for positioning the new body of water. The body of water will be sited on the poldervlak of the Groot Mijdrecht lake-bed polder. A poldervlak is defined as a vast, recurring geometrical unit in the measurement system used to structure of a lake-bed polder. The body of water will have its own water level. Constructing a dike or embankment around it can increase the water storage capacity.

In the peat polder on the east side of the polder complex, a body of water has been positioned that is much more autonomous in relation to the reclamation pattern. Turning the body of water in relation to the ditch pattern makes the length and direction of the existing water structure more visible. Turning more peat areas into wetlands reduces peat oxidation and therefore subsidence. However, the grassland is less usable for the farmers. The new element can generate a new programme in the polder, for example the creation of areas for water recreation or angling.

Lines of water

Widening the existing lines of water clarifies and reinforces the logic of the polder drainage system. The monumental *vaart* (navigable canal) and symmetry axis of the Groot Mijdrecht lake-bed polder are the carriers of this design experiment. Widened watercourses and branching *tochten* will be part of a network that makes the polder navigable at a level of 5.00 metres below Amsterdam Ordnance Datum. The network could be connected to the interlinking *boezem* system and *boezem* system of the Ronde Venen via two navigable locks.

In the peat polders, there are good links between the lines of water, and the network is much denser. The layout of the ditches provides ideal opportunities for canoeing, with connections to the artificial lake and the upland along the Amstel and the Kromme Mijdrecht. The landscape could be made even more exciting by creating variations in the ditch profiles, widening the ditches and alternating planted and unplanted areas. The idea of a peat-polder network is not actually new; it has existed for a long time under the name vaarpolder. In a vaarpolder, the plots of land are islands in the polder and are only accessible by boat. Many vaarpolders have disappeared from the landscape as a result of land reallocation. Those that remain are used mainly as nature reserves and/or as recreational areas.

2 Reh, W., Steenbergen, C. (2005). *Zee van Land, de droogmakerij als atlas van de Hollandse landschapsarchitectuur.* Stichting Uitgeverij Noord-Holland

1 km

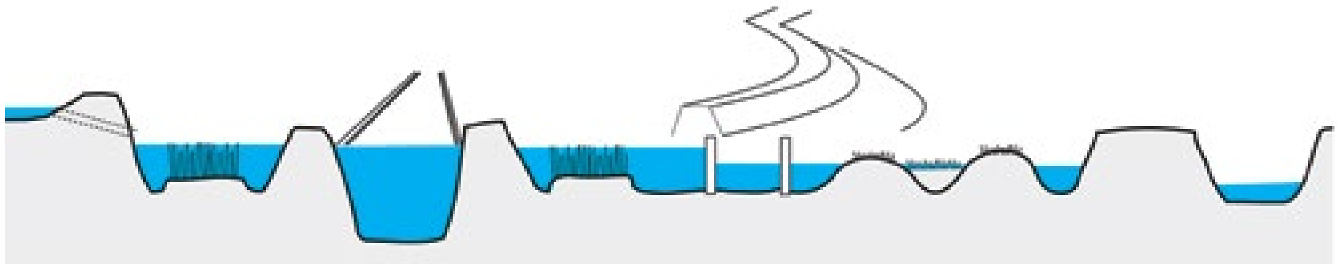
The Eendragtspolder

- lake-bed polder: on average 5.10 metres below Amsterdam Ordnance Datum
- area: 300 hectares
- province of Zuid-Holland
- Regional Water Authority: Hoogheemraadschap van Schieland en de Krimpenerwaard
- water storage: once every 10 years on average – max. 3 million cubic metres of water
- emergency water storage: once every 50 years on average – 1 million cubic metres of water
- project: water storage and emergency storage along the Rotte, recreational area
- design: Copijn Garden & Landscape Architects
- design and construction year: 2005-2013

◀ Topographical map 2009 and aerial photo of the new plan 2011 in the lake-bed Eendragtspolder

▲ Discharge system of the polder water of the Eendragtspolder

→	Flow direction
—	Contour polder
›	Weir
»	Lock
▟	Polder pumping station
(blue)	*Boezem* water
(grey)	Outer water



Section (from east to west) of the new design in the Eendragtspolder

The northern half of the Eendragtspolder, a lake-bed polder situated along the Rotte (a peat river), is being transformed into a water storage and recreational area. The existing pumping station will retain its function and is connected to the *vaart* along the Middelweg between the Zevenhuizerplas lake in the southern half of the polder and the northern section that is under development. The ensemble formed by the navigable lock, lock-keeper's house, mill and pumping station will also remain unchanged. This ensemble is not part of the Eendragtspolder. The mill and small pumping station are situated outside the polder and are used during dry periods to maintain the water level in the Rotte. Fresh water from the Hollandse IJssel is let into the ring canal of the Zuidplaspolder and flows to the pumping station via the Hennipvaart. The ring canal of the Zuidplaspolder (east of the Eendragtspolder) and the Hennipvaart serve as an interlinking *boezem* for a large drainage area.

The newly designed area of the polder is laid out as a water reservoir and emergency polder. When the water level in the Rotte is too high, water can discharge into the polder via a floodway in the dike. This prevents flooding in the urban areas further downstream. In other words, the storage capacity of the Rotte is increased by connecting the polder – or, more specifically, the rowing-course section – to the *boezem* system.

The design evolved through intensive collaboration between landscape architects, water specialists, ecologists and civil engineers. The water structure clearly has its own design, thereby giving the area a very distinct character. The lake-bed polder is on average 5.00 metres below Amsterdam Ordnance Datum, and a new polder layout has been created through excavation and raising. The interplay with the various ground levels and water depths creates a varied and water-rich polder landscape.

The most striking body of water, the rowing course, is parallel to the Rotte, and enclosed by two straight dikes. The rowing course is surrounded by underwater islands, which were added to the plan at a later stage. Their function is to prevent the growth of blue algae. The rowing course is situated in an artificial lake and is bordered by a new meandering embankment that is lower than the dike along the Rotte. When the peat river is at risk of flooding, water from the Rotte can be let in to a level of 0.70 metres below the crown of the meandering dike. If necessary, the water can be channelled from here to the lake-wetland area via a lock.

The main entrance to the new polder park is located on the winding embankment. The embankment is interrupted by a lock that connects the lake-wetland area to the rowing course. The location of this facility coincides with the centre of the park and acts as a landmark. A taut island layout forms the pivot point in the spatial composition of the two waterworlds.

The direction and dimensions of the lake-wetland nature reserve were inspired by the pattern of the parcelization in the polder. Low embankments allow water levels to fluctuate and provide for water storage. The subtle differences in ground level are reflected by the differences in vegetation; the area is emerging as a natural water garden. Along the raised periphery are the footpaths and cycle paths, and next to it there is a watercourse suitable for canoeing. Excess water from this can be discharged via an inlet into the canal.

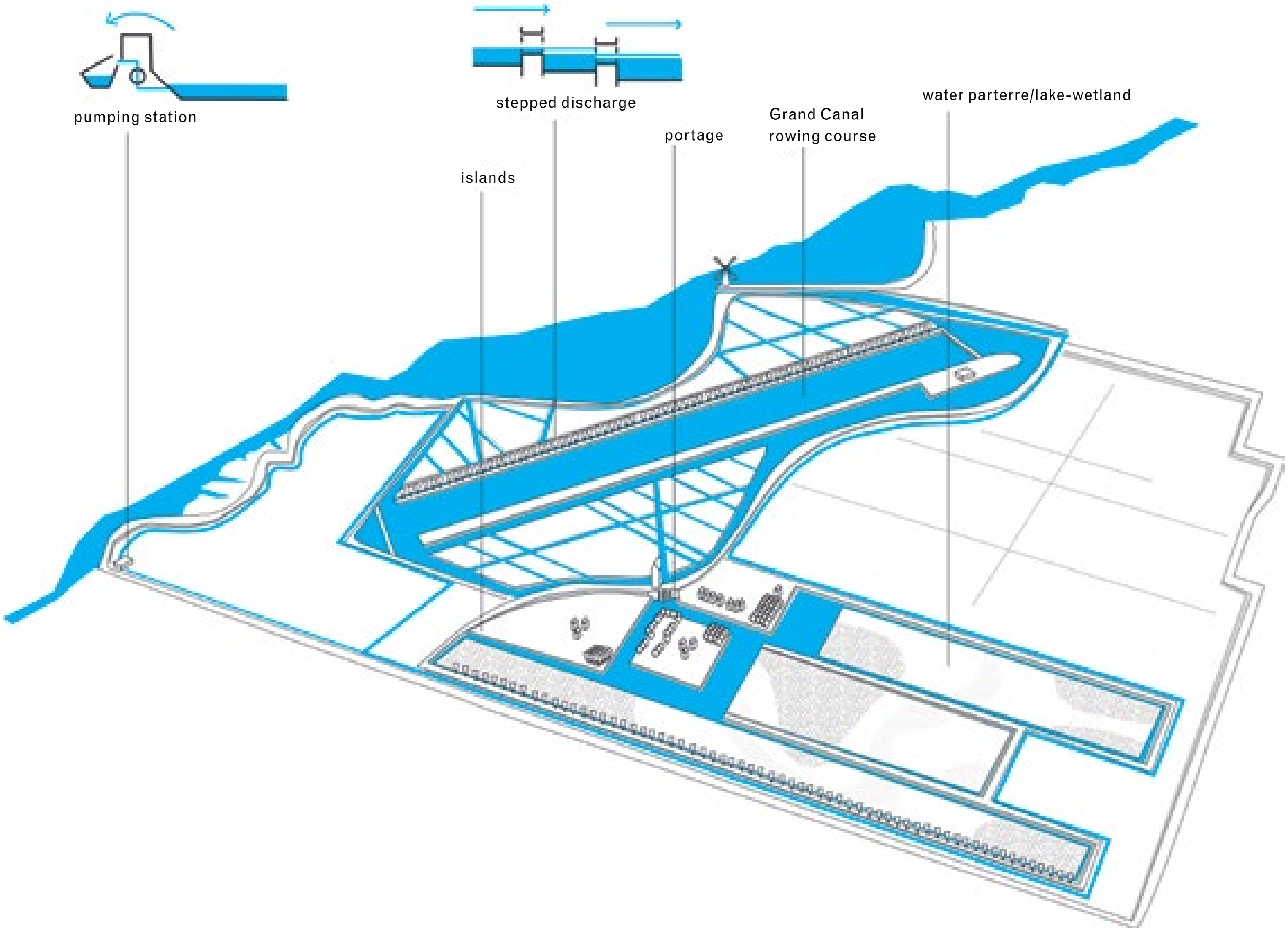
The northeastern corner of the polder is reserved for agriculture and is not connected to the water system in the polder park.

NAP

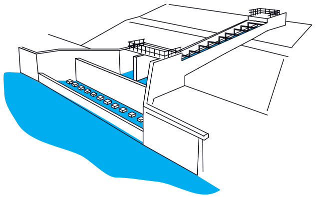
- Droog Maaiveld
- De Rotte -1,0m
- Polder -1,8m
- Lake wetland -4,50m
- Lake wetland -4,80 tot -4,50m
- Lake wetland -5,30 tot -4,80m
- Lake wetland -5,90 tot -5,30m
- Open water -6,45m
- Rowing course -9,10m
- Dike
- Contour polder
- Discharge direction
- Culvert
- Weir
- Lock
- Inlet
- Mill
- Inlet pumping station
- Pumping station
- Height difference in lake wetland
- Peat
- (Old) clay

◀ Water pattern and discharge direction of the new design in the Eendragtspolder projected on the natural landscape

▶ Drawing of *peilgebieden* of the new design

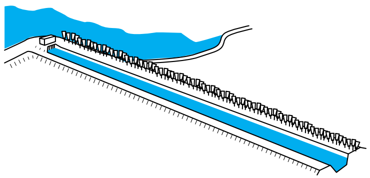

pumping station
stepped discharge
islands
portage
Grand Canal
rowing course
water parterre/lake-wetland

Cascade
form: open, channelled waterwork
movement: falling and flowing – technical
function: floodway



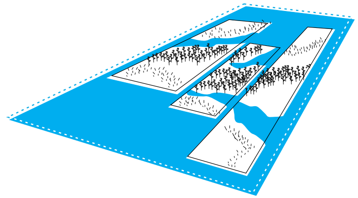
A floodway is a section of a lake or *boezem* where the dike has been lowered, and lets water into the polder in a controlled flow if the water level is exceeded. The floodway that is being built is a stepped structure, with an inlet into the Rotte. The construction is covered by the dike.

Grand Canal
form: straight line of water framed by trees
movement: mechanically flowing – technical
function: central canal



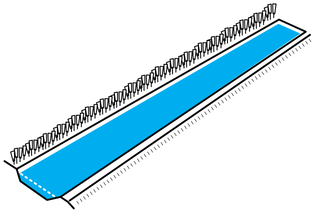
The main drainage channel is in the middle of the lake-bed polder, with three *tochten* running perpendicular to it. The *vaart* has been retained but, due to the new polder programme, only the two *tochten* in the east are still rudimentarily present. A row of trees gives a spatial accentuation to the main drainage channel in the new polder park.

Water parterre
form: geometric body of water
movement: still, varying in height
technical function: water-purifying



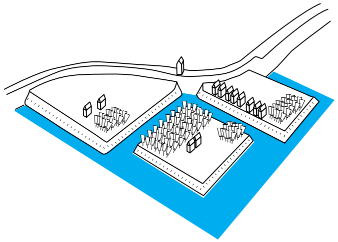
The lake-wetland area has been designed as a water garden. Embankments divide up the area into smaller areas with water on different elevations. This results in a rich palette of vegetation.

Grand Canal
form: straight, open, reflecting line of water/ rowing course
movement: still – technical function: water storage



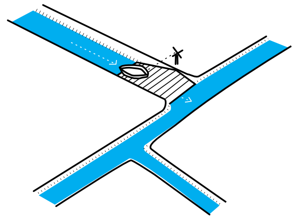
The rowing course is a water basin of 2.2 km length. It runs parallel to the Rotte but not to the polder water grid. When the water level is high, the rowing course is framed by two narrow paths lying in the water body. It's surrounded by underwater plots, designed to suppress the growth of blue algae. At low water levels, the plots become visible, creating a confrontation between the old and new ditch patterns. This part of the plan is also designed as an emergency storage area for the *boezem* water.

Islands
form: raised mound/terp and rectangular body of land

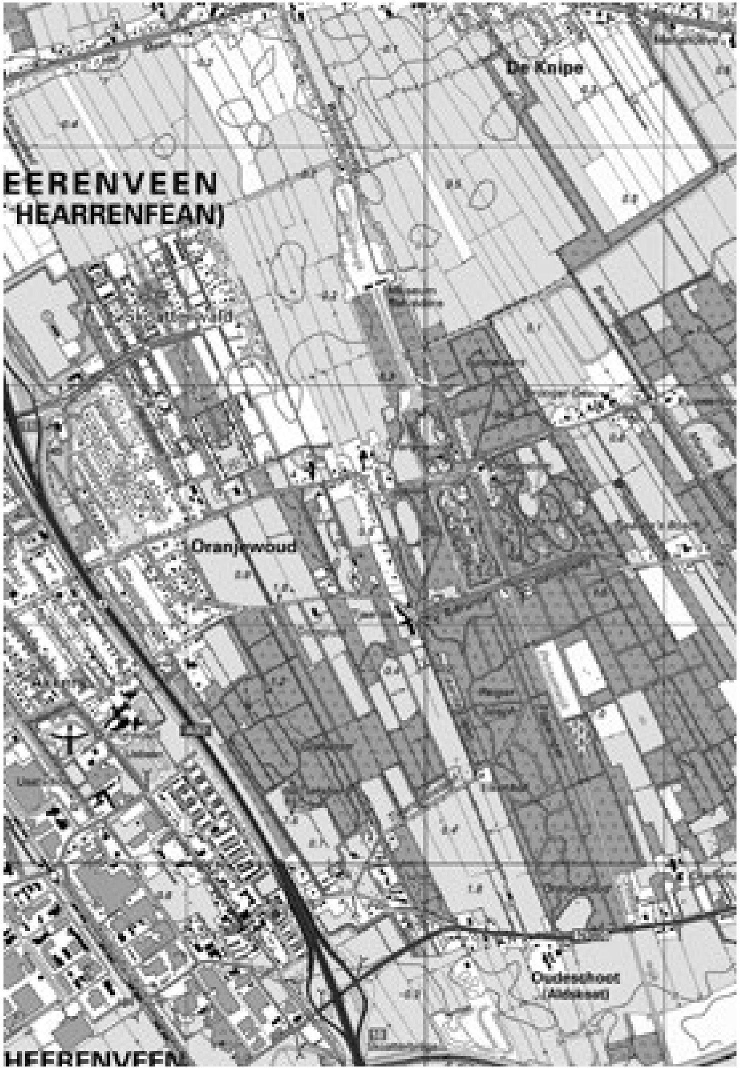


The Finish island of the rowing course is sited on a terp, a mound in the lake towards one side the course. The square islands on the winding embankment in the centre of the plan form the spatial 'hinge' in the design and also form meeting places in the park.

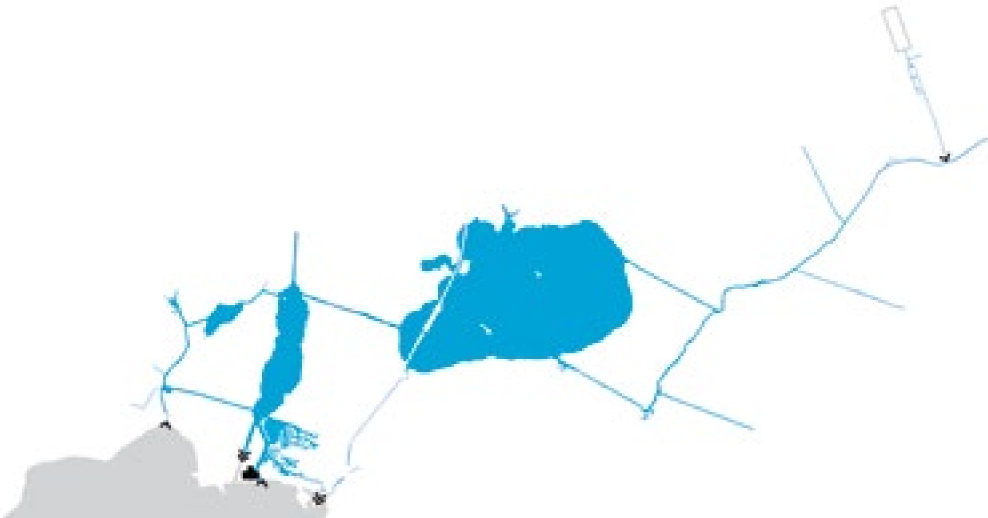
Portage
form: sloping plane – technical function: pulling upwards and sliding downwards



Two water-rich areas are connected by means of a floodway. As soon as there is too much water in the rowing course, the excess can be let into the lake-wetland area. At this point there is also a transfer point for small boats, known as a portage. The vessels can be transferred from one waterway to the other by pulling them up over the dike or embankment. This site is accentuated in the design by a landmark in the form of a tall building.


De Knipe
EERENVEEN
(HEARRENFEAN)
Oranjewoud
Oudeschoot
(Aldskoat)

1 km



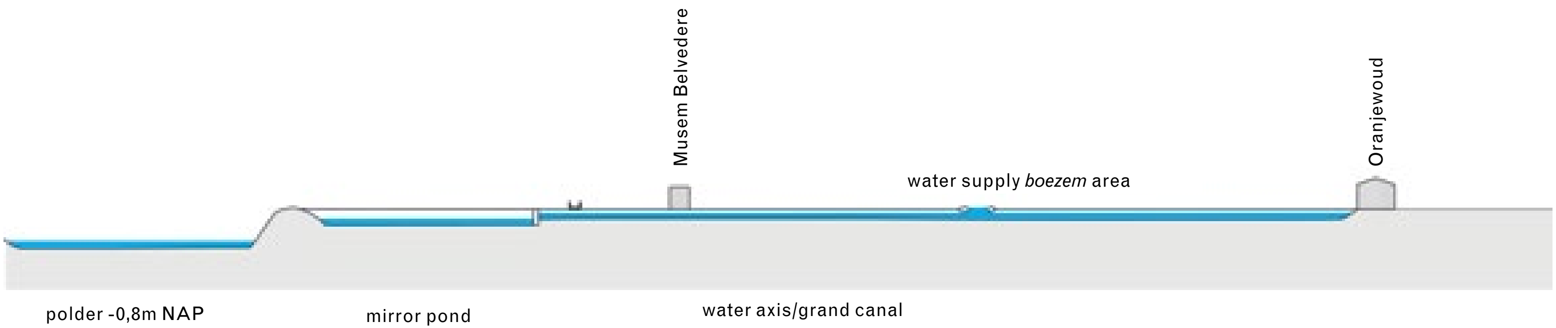
Museum Belvédère

- *boezem*: on average 0.50 metres above Amsterdam Ordnance Datum
- area: 23 hectares
- province of Friesland
- Regional Water Authority: Wetterskip Fryslân
- project: museum and museum garden, link to the Oranjewoud estate and water storage project
- design: M. van Gessel, Landscape Architects and E. Schippers, Architect
- design and construction year: 2003-2007

◀ Topographical map 2009 and aerial photo of Museum Belvedère

▲ Discharge system of the *boezem*, which is connected to the Museum Belvedère

Discharge direction
Contour polder
Weir
Lock
Polder pumping station
Boezem water
Outer water



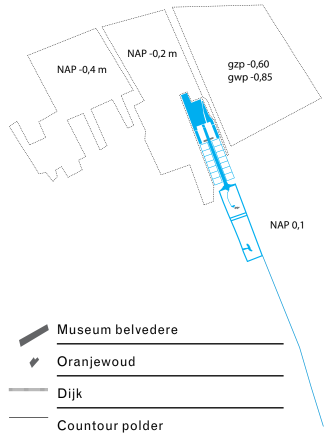
Section (from north to south) of Museum Belvedère site

On the boundary where the peat landscape meets sandy soils in the province of Friesland lies Oranjewoud, a 17th-century classic country estate. The French-born Dutch architect and designer Daniël Marot (1661-1752) took his inspiration from the structure of the surrounding polder landscape. In his design, the long axes of the polder parcelization pattern were translated into avenues and a Grand Canal. From the house itself, the garden and Wijde Wijk canal extend northwards, towards the open peat landscape. In 2005, the canal was extended and a park, lake and museum were added. The building, an elongated box in the shape of a bridge, was positioned in a spectacular position over the water axis, constituting a grand gesture. The canal terminates in mirror ponds. The water basin and the newly excavated, meandering main watercourse, in an east-west direction, mark the differences in elevation and soil type at the site.

The elongated plot on which the museum and garden are situated is on a level with the *boezem*. The water design is therefore a treatment of the *boezem* (a branch of the *boezem*) and increases its capacity. The *boezem* discharges in a southward direction, via the Tjonger River into the IJsselmeer.

The area around the museum and garden is sited in the peat polder. Water from the *boezem* can be let into the polder via a pumping station or a weir. The water management in the polder has changed radically due to new building and new insights into management methods (e.g. allowing more water into the polder). Here, the difference between the highest and lowest levels can be as much as 30 cm.[3]

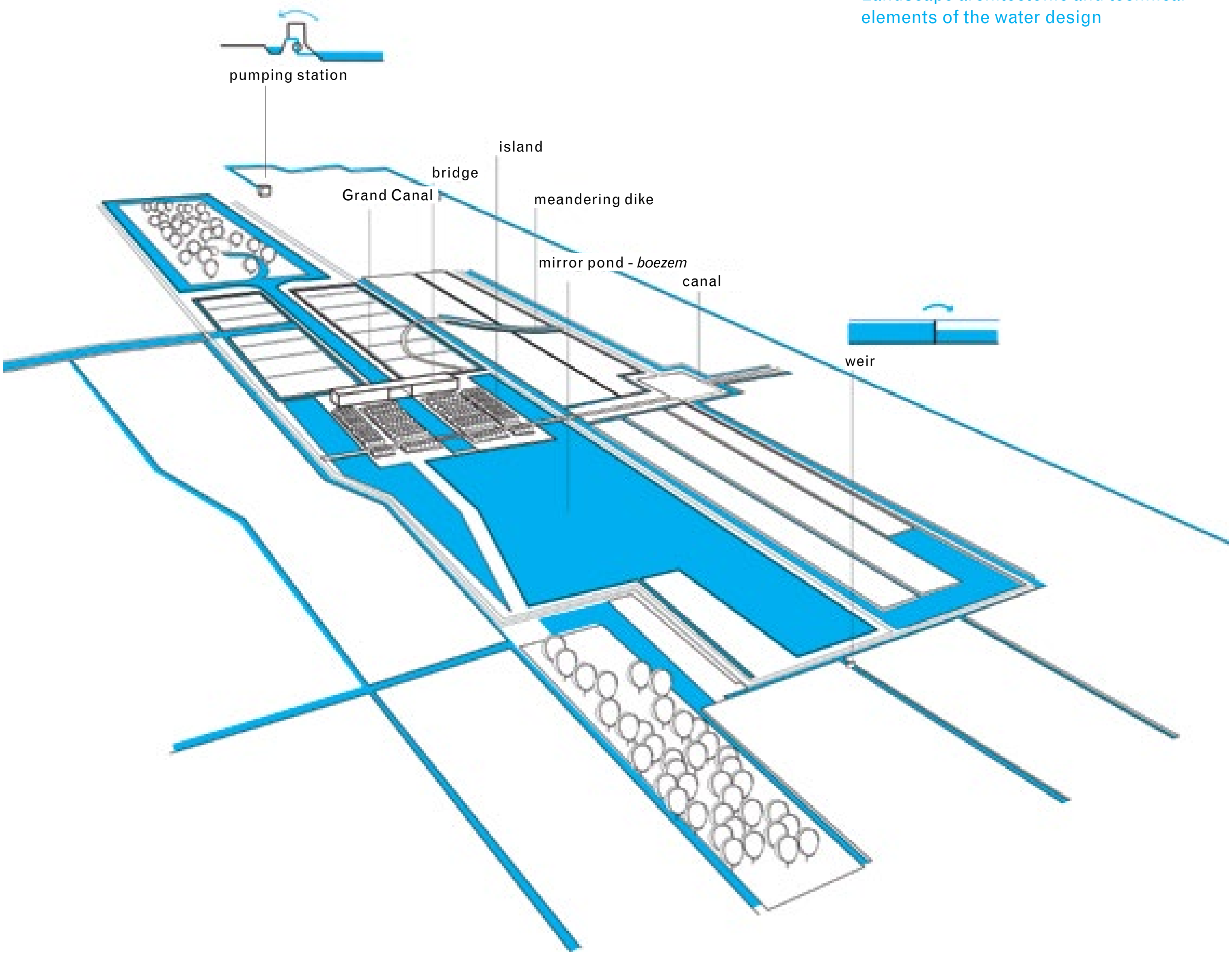
3 text based on, among others http://www.belvedere.nu http://www.museumbelvedere.nl/informatie/rondleidingen/museumpark http://www.bnagebouwvanhetjaar.nl Harsema, H. (red.) (2003/2007). *Landschapsarchitectuur en stedebouw in Nederland: Landgoed Oranjewoud.* Stichting Jaarboek uitgeverij i.s.m. Blauwdruk



▲ Water pattern and discharge direction of Museum Belvedère projected on the natural landscape

▶ Drawing of *peilgebieden* of the new design

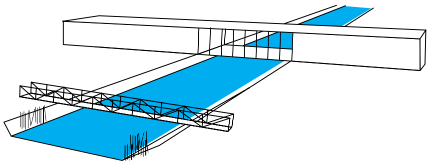
Landscape architectonic and technical elements of the water design

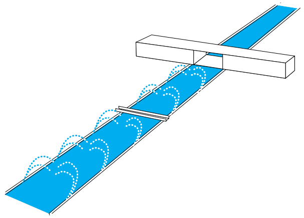


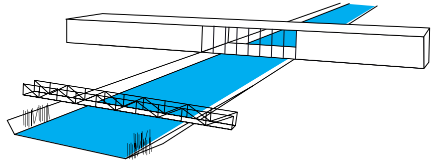
Grand Canal
form: straight, open channelled line of water
movement: still and mechanically flowing
technical function: *boezem*

Water spouts
form: small cylinders in the line of water
movement: spouting upward and falling

Bridge
form: building, encasing open land connection perpendicular to the line of water







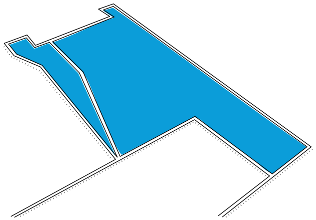
The Wijde Wijk canal is a strong spatial axis that links the old country estate and the new museum park. The '*wijk*' (another name for a transverse canal) is at least 15 to 20 metres wide and is enclosed by gently sloping banks.

On both sides of the Grand Canal there are waterspouts, small fountains that are directed to the water surface at an angle and make a splashing noise. The fountains also oxygenate the water, thereby improving its quality.

The museum spans the water axis in the shape of a bridge, as does the footpath. Its abstract form and the colour of the building makes the museum into a bridge itself. From the most public area of the building, the visitor has a view to the country house along the monumental line of water, with the foot-bridge in the foreground. In the other direction, the visitor has a view of the peat polder.

Mirror pond

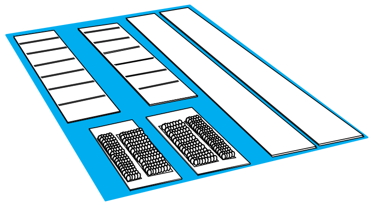
form: open, reflective body of water
movement: still
technical function: water storage at *boezem* level



The water axis terminates on the north side of the plan area in a body of water with islands. The islands frame the water axis. The water level can fluctuate and water for the polder is stored here.

Island

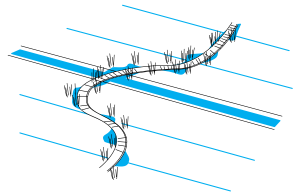
form: strongly outlined bodies of land



The size and situation of the islands in relation to the length and breadth of the lines of water and bodies of water are an important aspect in the composition of the landscape design. The edges of the islands are straight; the edge is formalised. This is in sharp contrast to the irregular edges of the surrounding peat plots.

Wooden walkway

form: meandering wooden pathway on bodies of land and water



Wooden pathways are laid through marshy areas or sensitive habitats to enable people to make their way across those places without difficulty. The narrow path winds through the rough planting, which changes in height and colour with the seasons.


Tweede Bedijking der
Mijdrechtsche Droogmakerij
De Ronde Venen
Mijdrecht
De Hoef
Polder de Derde Bedijking
Polder

1 km

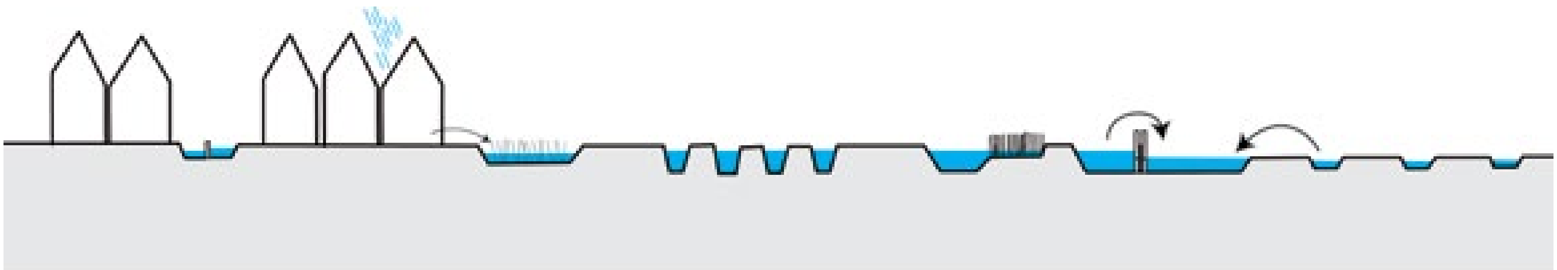
Wickelhof Park

- lake-bed polder: on average 5.00 metres below Amsterdam Ordnance Datum
- area: 11 hectares
- province of Zuid-Holland
- Ronde Venen, the ‘Derde bedijking’ polder
- Regional Water Authority: Amstel, Gooi & Vecht
- project: polder park with water purification for new housing development
- design: BRO Vught (consultants in spatial planning, economics and environment)
- bridges and spatial elements: Atelier Veldwerk R. Luijters and O. Dirker, artists
- design and construction year: 2003-2007

◀ Topographical map 2009 and aerial photo of the lake-bed polder the 3e Bedijking including the Wichelhofpark

▲ Discharge system of the polder the *3e Bedijking*

→	Discharge direction
—	Contour polder
›	Weir
»	Lock
▲	Polder pumping station
■	*Boezem* water
■	Outer water



Residential area
(NAP -5.80)m

Park
(NAP -5.70 m)

Greenhouse area
(NAP -5.80 m)

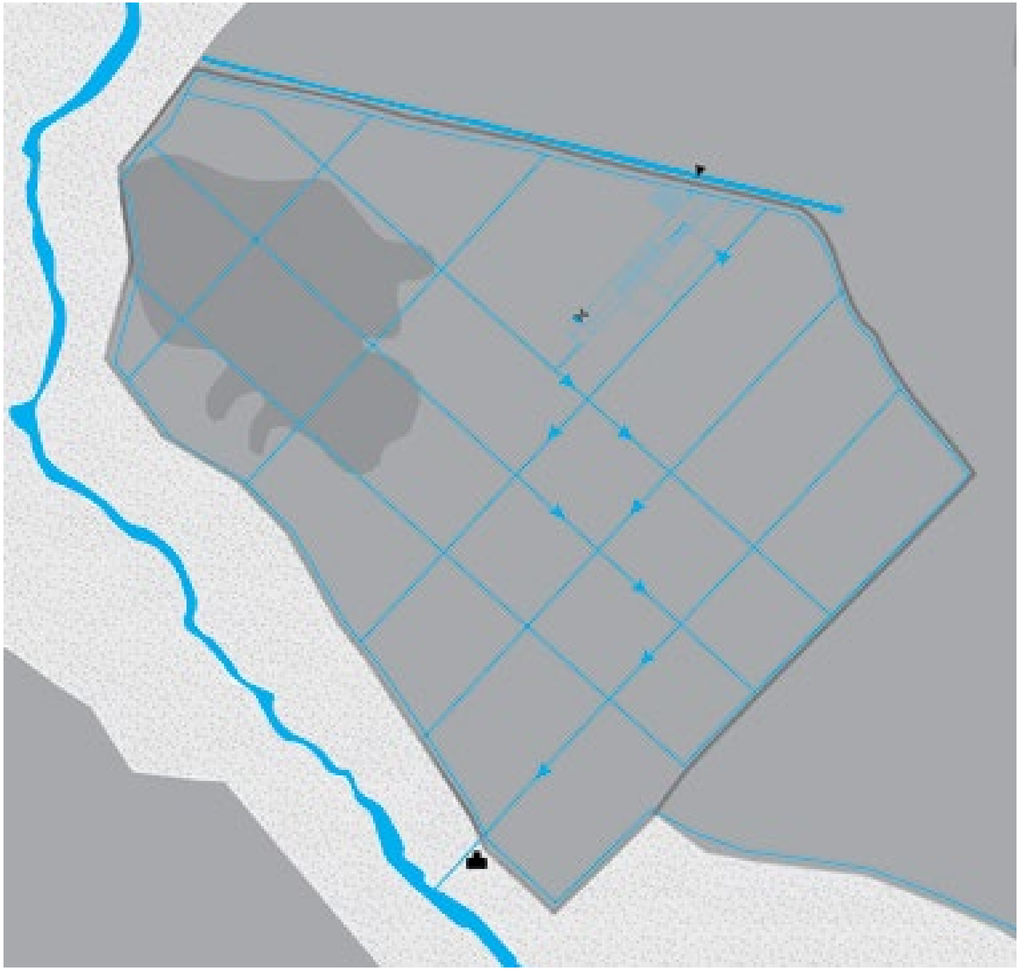
Section (from southeast to northwest) of the Wickelhof-park

Wickelhof Park is situated in the Ronde Venen, in the 'Derde bedijking' polder. The park extends over 3 plot widths, 2 plot lengths and a residual plot adjacent to the Kerkvaart canal, which is on a higher level. The polder and park drain into the Amstel peat river in the south-west of the polder, via the pumping station.

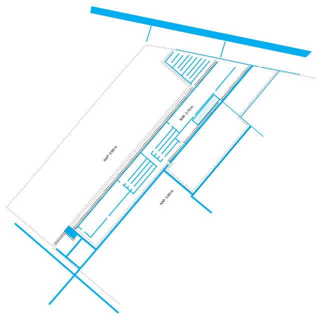
In terms of water technology, the park forms a single entity with the adjacent new residential development. Excess water can be discharged into the polder in purified form. When there is a shortage, water can be let in from the interlinking *boezem* (the Kerkvaart canal). Rainwater that falls in the residential area is stored in the park. The water storage area compensates for the shortage in water irrigation, resulting from the damming-up of ditches and hard-surfacing of the land for housing and roads in the new development. The roof water from the buildings is discharged directly into the park. Street water is channelled through a separate sewage system to a filtration area situated in the lower central part of the park. The street water remains in this area for a period of time; it is filtered by the marsh plants and marginal plants, and is then channelled into the park water via an overflow.

In order to provide optimum storage for the water from the area, the water level is regulated by a variable weir and can fluctuate between 5.80 and 5.70 metres below Amsterdam Ordnance Datum. Water is let in during dry periods, when the water level is likely to fall to 5.80 metres below Amsterdam Ordnance Datum. The waterworks in the park were designed by artists. Their source of inspiration was the Dutch polder landscape, and their approach was therefore sober and pragmatic. The design of the culverts is a good example of this. The culverts are flanked by two vertical poles, the purpose of which is to protect the pipes from being damaged by mowing machines. With this simple intervention, the water's route through the park is made visible. The water is made accessible by means of jetties in special places, and various bridges. The elements used are all different, but are related in terms of their form and materials (wood, steel and concrete).[4]

4 text based on, among others Atelier Veldwerk R.J. Luijters en O. Dirker (2008). *Informatiebord bij het park*

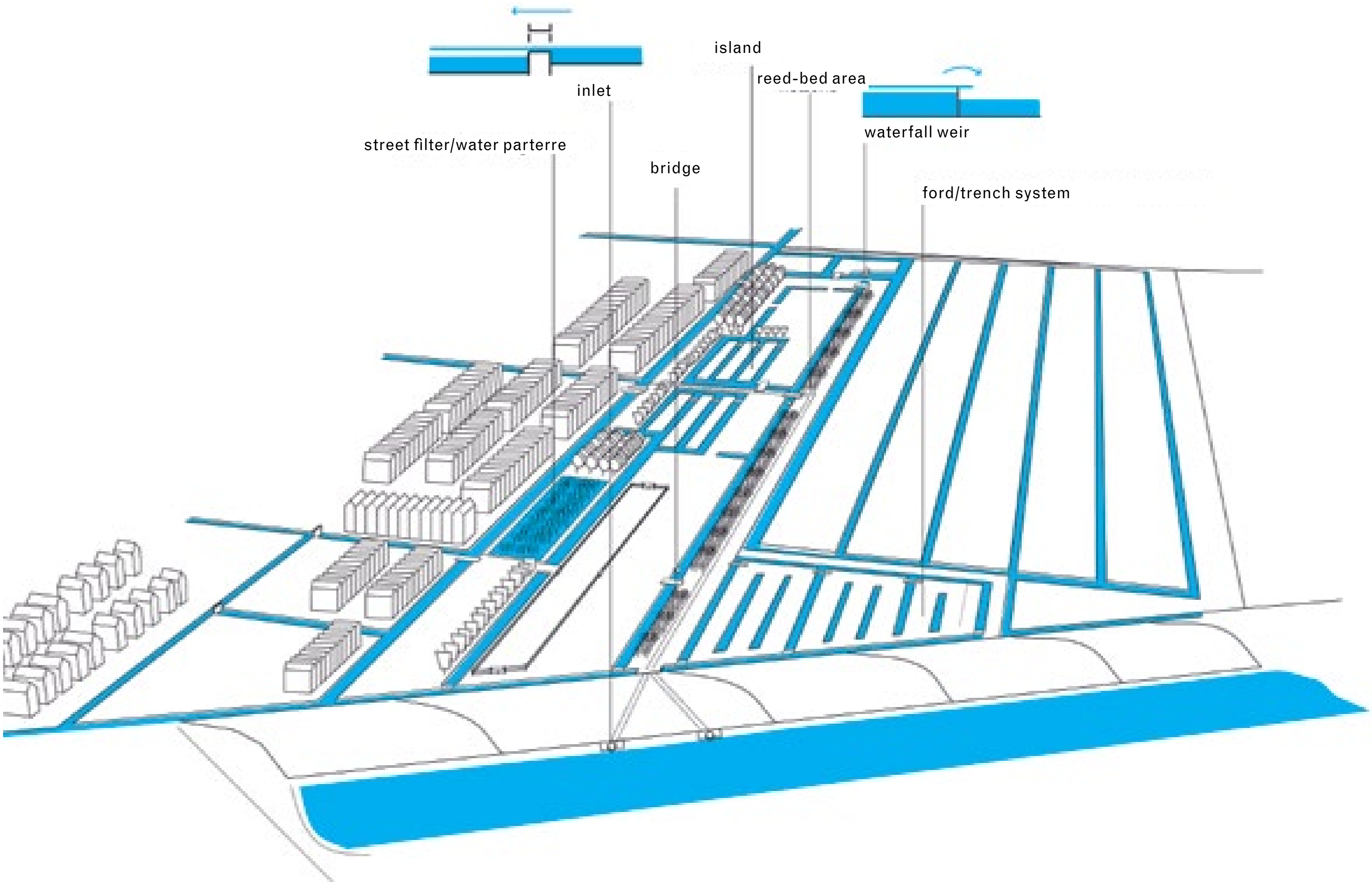


Peilvak
Dike
Contour polder
Discharge direction
Inlet
Weir
Pumping station
Clay
Old clay
River bed

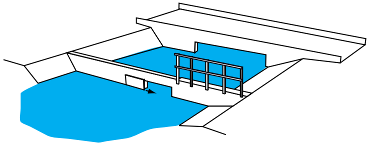


Water pattern and discharge direction of the *3e Bedijking* projected on the natural landscape

Drawing of *peilgebieden* of the new design

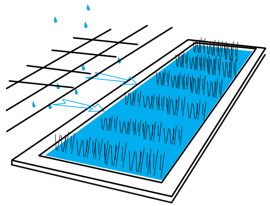

island
reed-bed area
inlet
waterfall weir
street filter/water parterre
bridge
ford/trench system

Waterfall
form: open, bridge-like waterwork
movement: retaining and falling
technical function: variable weir, inlet



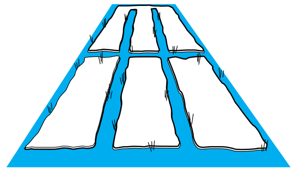
A variable weir near the main entrance to the park is clearly visible. It lets excess water from the park into the polder. The water comes from the residential area and has been purified. The weir marks the boundary between the park and polder landscape.

Water basin
form: rectangular, sometimes dry body of water
movement: temporarily dry, varying in height, or still
technical function: water-purifying



Street water from the neighbouring residential area is channelled to a filtration area through a separate sewerage system, a low-lying section of the park with marsh plants and marginal plants. The area is surrounded by low embankments. The purified water flows into the park through a spillway.

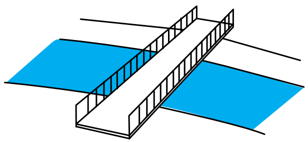
Water parterre
form: geometrically sectioned body of water
movement: still, varying in height
technical function: water-purifying



The water storage area is not designed as a lake, but as a play of lines created by parallel trenches. Planting is varied due to the fact that the trenches sometimes contain water or are temporarily dry, and the fluctuating water level of the storage area can be clearly seen.

Bridge

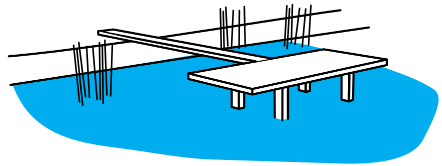
form: open crossing point, reinforces the line of water



The park has 7 bridges; some have railings, some do not. All the bridges are different and are of a simple, flat design. Their positioning emphasises the flatness of the polder landscape. The materials used are wood, steel and concrete. The perpendicular link over the ditches means that the water landscape can be clearly seen and experienced.

Balcony

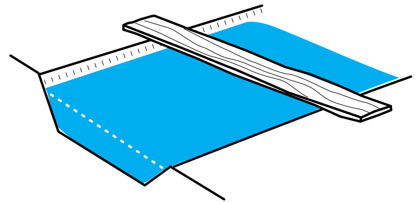
form: open jetty close to the body of water



This jetty, which widens into a terrace at the end, is situated by the entrance to the park. The plateau ‘hovers’ above the *waterplein* (‘water square’), giving a view of the variable weir. The polder water and park water converge in the rectangular basin.

Ford

form: open walkway/bridge close to the line of water



The materialisation of the waterworks in the outlying section of the park has been kept simpler and more informal. Here the ditches are traversed not by bridges, but by simple wooden boards, marked by a pole that also provides some support while crossing. Care and concentration are required to cross over the ditches.

1 km

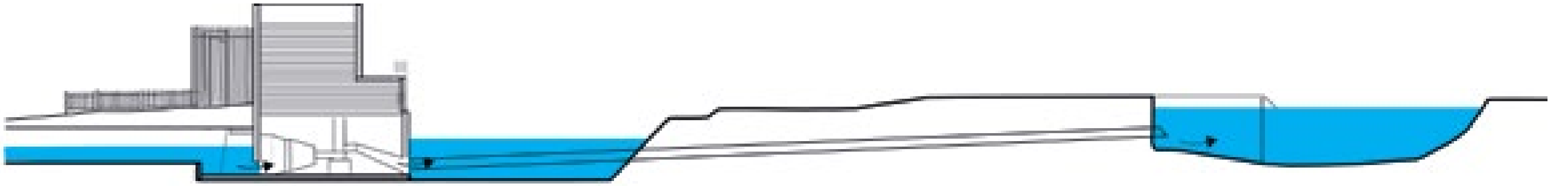
Topographical map 2009 and aerial photo of the Onner-polder and the Onner- pumping station. The West-erbroekster-madepolder, on the other site of the *boezem* is transformed into a nature area.

Arial photo of the peat polder Onnerpolder and the Onner-pumpin station

Discharge system of the Onnerpolder.

Onnerpolder pumping station

- peat polder: on average 0.20 metres above Amsterdam Ordnance Datum
- area of polder: 337 hectares; area of building: 1200 m3
- province of Groningen
- Regional Water Authority: Hunze & Aa's, part of the Dollard *boezem*
- project: pumping station with a viewing plat-form
- design: bureau Onix bv Architects, project architect A. van de Beld
- design and construction year: 2004

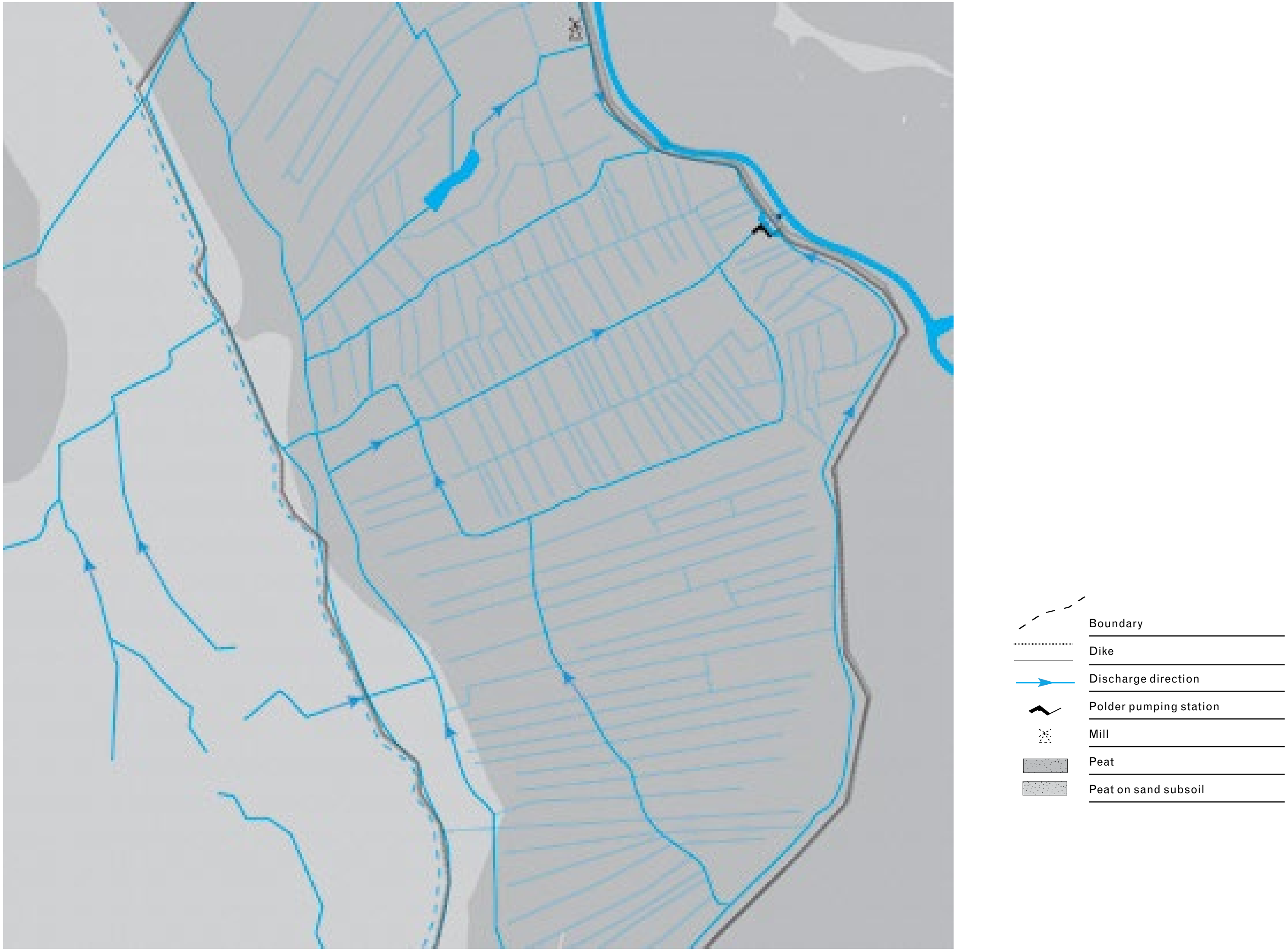


Section (from southeast to northwest) through the Drentsche Diep and the pumping station

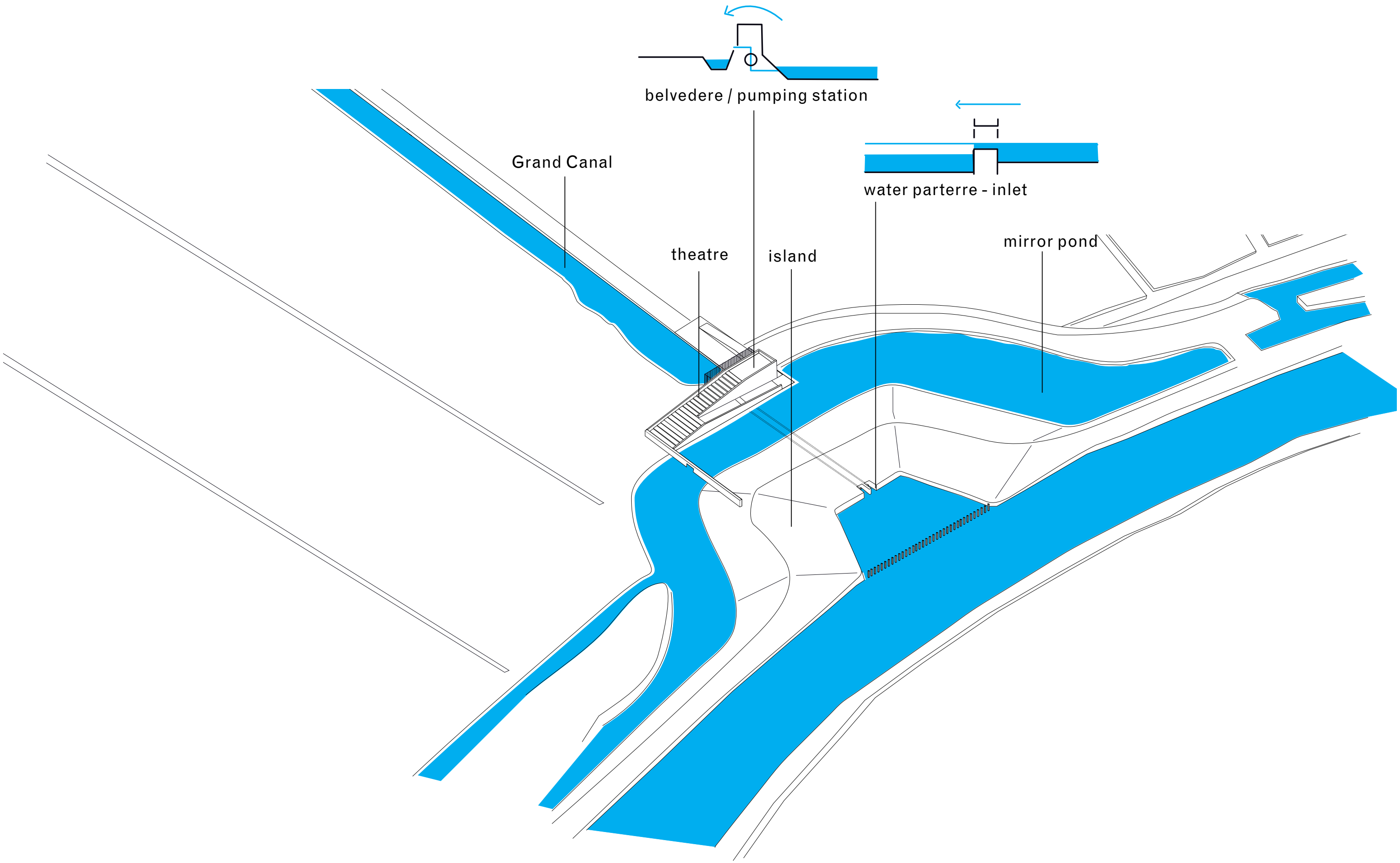
The pumping station stands like a bastion between the watercourse and the Drentsche Diep, the *boezem* on a higher level. Water drains into the Wadden Sea (water outside the system) via the Dollard. On the west the polder is bordered by the natural relief of the Hondsrug sand ridge, and on all the other sides by dikes. The water from the Hondsrug flows into the polder, and is pumped out again by the new Onner pumping station. Most of the polder is open grassland on peaty soil, with elongated parcelization, extending between the Hondsrug and the Drentsche Diep. Only in the middle of the polder are there 3 strips of land perpendicular to this; there is a theory that this was once a separate polder. The new pumping station is connected to the central axis of this twisting parcelization pattern.

The pumping station forms part of an interesting ascending route from the polder floor to the roof of the building, with views over the vast nature reserve that is being created on the other side of the Drentsche Diep. The route has been designed in an architectural way and extends from the built area at the foot of the Hondsrug, parallel to the watercourse, via a forecourt, up the slope and steps onto the viewing terrace on the roof. The route then continues via the bridge to the island, where the drainage point into the Drentsche Diep can be viewed. The visitor follows the same route as the water that is being pumped up onto another level.

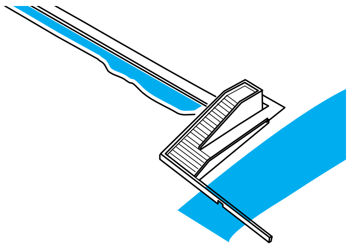
In the design all aspects of the pumping station, including culverts, duckweed barriers, weirs and pumps, are integrated into the building. The sculpture-like pumping station is constructed mainly of concrete. The Drentsche Diep, a remnant of the old watercourses that shaped the Groningen landscape, has been widened where possible to create more space for the *boezem* water. This was also the case on the place of the Onner pumping station, making it possible to turn the water inlet into a visibly designed site in the course of the *boezem*. The recess in the *boezem* also shaped the dike. The wide dike ditch ‘disconnects’ the dike, creating the impression of an island. The bridge leading to it reinforces this impression.


Boundary
Dike
Discharge direction
Polder pumping station
Mill
Peat
Peat on sand subsoil

◀ Water pattern and discharge direction of the Onnerpolder projected on the natural landscape

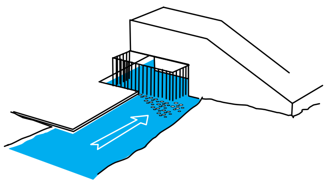


Grand Canal (latent)
form: open, channelled waterwork
movement: mechanically flowing
technical function: watercourse (*wetering*)



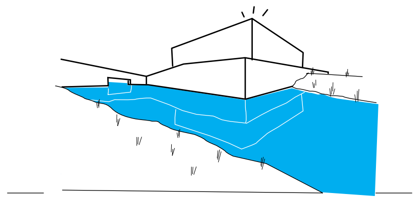
The most central *wetering* in the polder is connected to the pumping station. This *wetering* does not differ from the others in terms of dimensions and form has not been elaborated in architectonic terms. Along the *wetering* there is a slightly elevated footpath, which gives the watercourse a somewhat stronger accentuation.

Duckweed barrier
form: open, cage installation, waterwork
movement: falling and flowing
technical function: filters solid elements



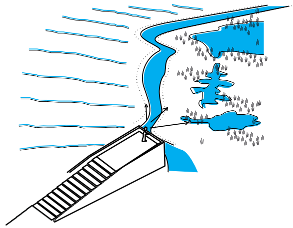
As the designers themselves indicate, their aim has been to integrate the barriers near the pumping station into the design. This is not usually the case, which means that the cage installation tends to overshadow the design of the pumping station. The installation is constructed from metal rods, and filters the water in the watercourse leading to the pumping station in order to protect the pumps.

Pumping station
form: enclosed waterwork following the movement of the water
technical function: pumping upward, duct



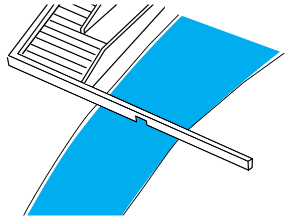
The building stands like a sculpture in the landscape. Adding to the programmatic features made it possible to increase the volume of the building. Because the walking route extends over the building, the pumping station becomes part of the polder landscape. The walker and the water follow a similar route.

Belvedere
form: raised, open, viewing point



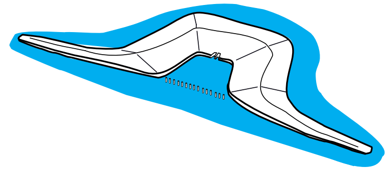
Above the machine room in the pumping station, the terrace is enclosed by high roof edges, creating a protective outdoor space. This high viewpoint in the middle of the peat wetlands affords the visitor views of the birds and watercourses extending as far as the horizon.

Bridge
form: open crossing point, frames the line of water

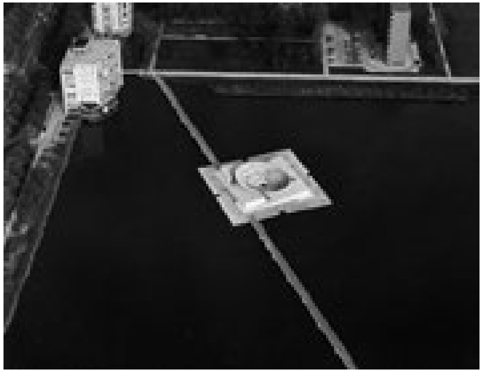


The bridge forms part of the route, and leads the walker over the polder water to the island. The bridge anchors the pumping station in the landscape. The bridge has only a small opening for water, emphasising the fact that the water hardly flows at this point. The bridge is reflected in the body of almost-still water.

Water parterre
form: open, framed body of water
movement: eddying
technical function: inlet



Walkers can follow the route that the water takes from *wetering* to *boezem*, but the flow of water is largely hidden from sight. On the island, at the edge of the *boezem*, a grid marks the site where the water is pumped out. The *waterplein* ('water square'), sepa-rated from the *boezem* flow by a row of poles, creates space for eddies that are created when the water is pumped through.



The park Luna, a water park is designed by bureau Hosper. It's situated in the lake-bed polder Heerhugowaard. Part of it (photo left and right upper row) is design in the shape of a labyrinth and functions as water purification.

The center of the neighbourhood Prinsenland (Rotterdam) consist of a rectangular shaped lake. Within the lake lays a rectangular island toped by a sculpture. This place marks the deepest point of a lake- bed polder in the country.

The plan *Natte Ogen* (Wet Eyes) consists of different basins for water retention on polder, city and *boezem* level and is designed by the atelier de Lyon.

The main building of the Johnson-Wax factory is situated in a shallow water basin in the lake-bed polder Groot- Mijdrecht. The building is designed by the architect Maaskant and stands on pillars, which symbolises its precarious position under the sea level.

Conclusion

The projects have been chosen as examples because here water plays a dominant role in the design and are incorporated in an architectural way. What is worth noting, however, is that each of the proposed projects occupy only a part of the polder in which they are located, and the relationship to the locations' unique character does not appear to have formed the starting point for the adaptations.

In the case of the Eendragtspolder project, the link between the designed water system and the polder water has not been developed further in a spatial sense, except at the periphery of the project. In the south, the project is bordered by the central canal that is connected to the polder pumping station. The water axis is reinforced by a row of trees along the edge of the design. The polder drainage system is channelled around the newly designed area. Existing waterworks are not being adapted, although new waterworks such as the *boezem* inlet and the portage are being introduced. The pattern of the former lake-bed polder was adapted in the area around the rowing course and the lake-wetland area. Here, different elevations have been introduced in the areas of land, creating interplay between the fluctuating water level and the existing parcelization pattern.

The Museum Belvédère project is an adaptation on the level of the *boezem* water. Intensive study is required in order to understand the relationship to the adjacent, lower-lying polders. The edge of the higher *boezem* area has not been transformed in an explicit way; the inlets that allow *boezem* water into the polder do not play a spatial role in the design. Equally, the pumping station on the eastern branch of the *boezem* does not play a role in the design in terms of landscape architecture, although the project creates a subtle interplay with the water pattern. The composition of canal, bodies of water and islands is clearly distinct from that of the surrounding polders. The monumental canal is the spatial carrier of the plan.

The Wickelhof Park project forms a physical link between the urban extension and the agricultural parts of the polder. The project involves compacting the pattern of ditches within the park, and reducing the scale of the polder to the scale of a park. The routes through the park articulate the denser water pattern. The variable weir at the entrance dramatises the point of contact between park and polder. No visible spatial relationship to the *boezem* has been created, although water can be let into the polder at this point. This is perhaps due to the fact that, in terms of civil engineering, the *boezem* is not part of the water system in the lake-bed polder, the assignment area.

The last project in the series is the Onnerpolder pumping station. The function of the pumping station has been augmented by means of an intriguing route and many points from which views of the surroundings can be enjoyed. The designers modified the immediate context of the building in order to anchor it in its locus. The relationship to the *boezem* has been well elaborated, in contrast to the relationship to the *wetering* and the water pattern of the polder.

Perspective and conclusion

As the water rises, the polder land is sinking as its current agricultural function is maintained. The future of the water system therefore partly depends on the development of land-use functions. This conclusion shows that solving current water issues is not only a matter of water management, but, again, a matter of restructuring the polder landscape. This time, the restructuring is not aimed at improved efficiency for agriculture, as in the land reallocation process undertaken in the previous century, but at creating a mix of functions. The current mono-functionality of the polder as farmland should be augmented with a spatial layering aimed at integrating other functions, so that more water can be let into the landscape.

As discussed in Chapter 2, the urgency of the water issues has placed them on the national and international agenda.

The aim of Water inSight is to make a design-based contribution to the transformation of the polder water. First and foremost, this requires knowledge, which is needed to explain the complex polder-*boezem* system in a comprehensible way, in words and images. To do so, it proved insufficient to ask the Regional Water Authorities for their charts and map materials and to reproduce these. The material had to be represented in an accessible way, to make the system understandable. We found that many hydrological maps, including the digital versions, were not up to date. Parts of the water system were not shown, or in some cases were shown in the wrong location in the polder. When the experts were consulted about this, we received conflicting answers on a number of occasions, and it was down to us to interpret the maps in a logical way. Because the water system is constantly being modified, mapping is problematic – but nonetheless vital. Another difficulty we encountered in explaining the form and functioning of the polder water was the fact that there is no universally accepted framework of terms. In practice, different water authorities use different terms. For this reason, it was necessary to define the polder-water terminology ourselves, using a range of sources.

Having visualised the polder-*boezem* system and unravelled its complexity with the help of the Polder Atlas of the Netherlands, the actual purpose of Water inSight is to stimulate the landscape-architectonic adaptation of water forms and water patterns, which are – with a few exceptions – utilitarian and technically functional in nature.

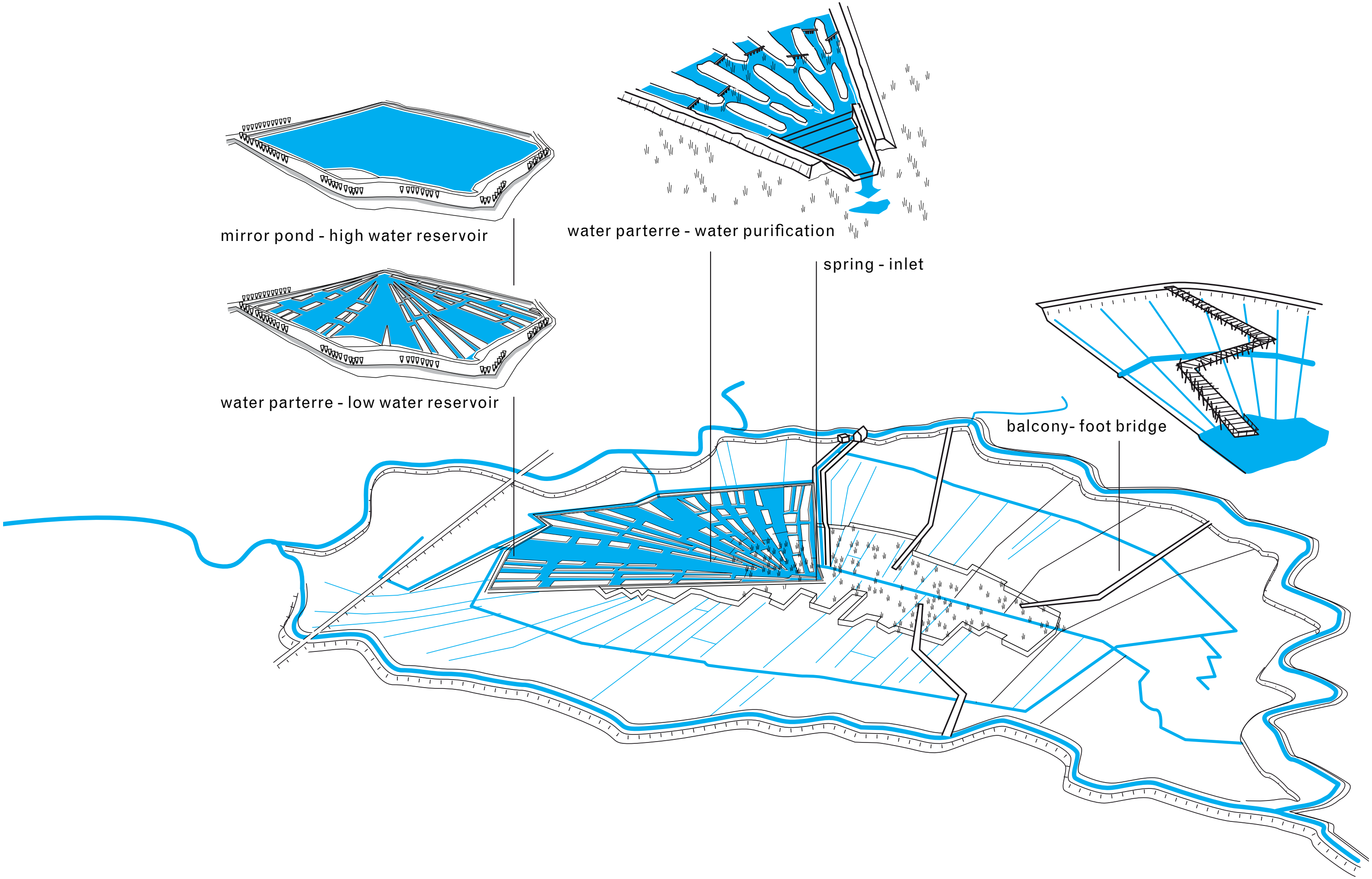
As our source of inspiration we turned to the origins of landscape architecture: the classical villa. The virtuosity of villa design is to be found in, among other things, the dramatisation and staging of, say, a watercourse in a specific locus.

The projects presented in Chapter 5 show that the designers are also familiar with elements belonging to the classical repertoire and have used them in their designs. It is notable, however, that there is little evidence of a connection to the polder water being sought in the projects. Perhaps this can be attributed to a lack of available knowledge regarding the location. The spatial relationship between the water in the projects and the water in the polder in which they are situated could be developed further in architectonic terms.

Drawings – a refinement of work carried out by students – sketch a direction of thought and show how the polder can be transformed in the framework of a landscape-architectonic exercise. The examples focus on the water throughout the polder, the water pattern and the adaptation of crucial points in the water system. New waterworks are also being introduced into the polder. They are positioned in such a way as to reinforce the 'genius loci' of the polder concerned. Together, the interventions form a landscape-architectonic composition that provides the polder water with an explicit spatial articulation and introduces new functions such as energy extraction, nature development and recreation into the polder. Experiments are being carried out with the Ronde Hoep, a peat polder, and the Schermer, a lake-bed polder.

1 Sijmons, D. (1998). *Landschap.* Architectura & Natura Press

2 MSc 1, 2nd quarter (2010/2011). Track Landscape Architecture at the TU Delft Bouwkunde


mirror pond - high water reservoir
water parterre - low water reservoir
water parterre - water purification
spring - inlet
balcony- foot bridge

The fan: design-driven research in the Ronde Hoep

In the first example, the Ronde Hoep, we looked at how water storage can be used to make the unique fan-shaped parcelization pattern visible. The addition of more water can enhance the stimulating perspective of the fan-shaped parcelization from the motorway, which is at a higher level than the polder and cuts through its northernmost point. To achieve this, however, it is necessary to fell the woods that obscure the view over the polder. The 'water field' could be part of the new nature reserve and could be used for water purification purposes. The flow of clean water from the purification system into the nature reserve, the transition from the fan to the island, has been elaborated as an architectonic element. Limited access could be allowed, preferably linking up to the recreational route along the Amstel.[3]

3 Luijendijk, P., Ottevanger, E., Snoep, K. (2011). Student work MSc 1 Landscape Architecture, TU Delft, Faculty of Architecture

◂ Design by research: Water works and water patterns of the peat polder Ronde Hoep transform into a landscape architectonic composition.

Water parterre

form: perspectival plots of land become islands in the body of water
movement: still
technical function: water storage

The polder's unique parcelization pattern can be transformed into a water parterre by creating a new relationship between the water and parcels of land. When water levels are low, the perspectival effect of the parcel form is particularly visible from a high vantage point.

Mirror pond

form: reflective body of water
movement: still and flowing
technical function: water storage

The area of fan parcelization is edged by an embankment that allows for a fluctuating water level for water storage. The water can temporarily reach a level at which the parcelization pattern is no longer visible, thereby creating a reflective body of water.

Spring

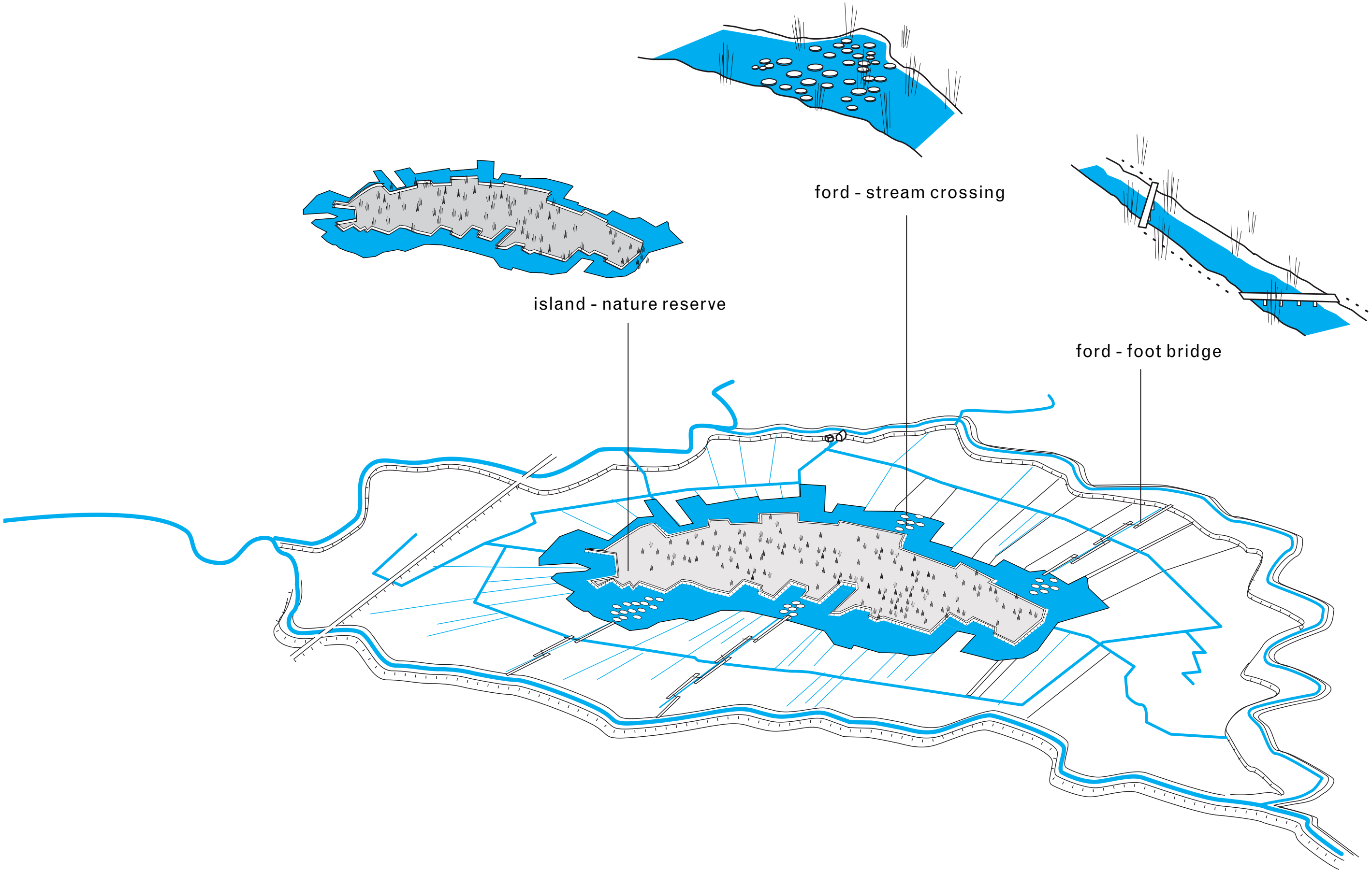
form: open, channelled waterwork
movement: falling and flowing
technical function: inlet

When water surges or spurts out of the ground and/or a built element, it forms a spring or a fountain, respectively. In the lowlands there are hardly any springs in the classical sense of the word. However, the connection between one area of water and another can be elaborated to create a spring, particularly if the water is clean and pure.

Footbridge/balcony

form: horizontal on the water

Water in the polder is usually difficult to access; this is solved by introducing jetties and footbridges close to the surface of the water. In this design, the footbridges function as a balcony, because they end in the marsh rather than connecting banks on either side of the water.



ford - stream crossing
island - nature reserve
ford - foot bridge

The island: design-driven research in the Ronde Hoep

A wetland nature reserve is currently being created in the middle of the Ronde Hoep peat polder. All the ditches in this area are being dammed-up in order to allow for an independently fluctuating water level of between 2.80 and 2.45 metres below Amsterdam Ordnance Datum. A pipeline supplies the area with fresh, phosphate-free water in order to encourage and support the growth of flora and fauna native to the area. The polder water itself is too polluted for the envisaged habitat creation.

The middle of the Ronde Hoep polder is hardly visible or accessible from the edges of the polder, formed by the dikes along the peat rivers. In this experimental design therefore the proposal is to construct a ring of water around the nature island in order to make its new function in the polder visible. The ring of water varies in width depending on the ground level in the relevant part of the plot. The width of the ring increases in proportion to the level of the ground. The form of the water ring echoes the relief of the polder floor. The water in the ring is directly connected to the surrounding polder ditches. The excavated soil has been used to construct a low embankment around the nature reserve, which reinforces its identity as an island. It would be useful if the polder water could be purified in the ring to the degree that it could be let into the nature reserve. A selected number of fords or stepping stones could be created to allow visitor to access the area.[4]

Island

form: piece of land in a body of water

An island is land that is surrounded by water on all sides. The low embankment and ring of water reinforce the area's identity as an island – a secret place.

'Nature reserve'

form: dynamic body of water with vegetation
movement: still
technical function: water-purifying

The characteristic jagged edges of the ditches can be accentuated by giving more space to vegetation from different phases in the transition from land to water. This comprises types of vegetation that occur on the border between land and water, such as floating mat vegetation, marsh ferns, sphagnum-reed marshes and quaking bog.

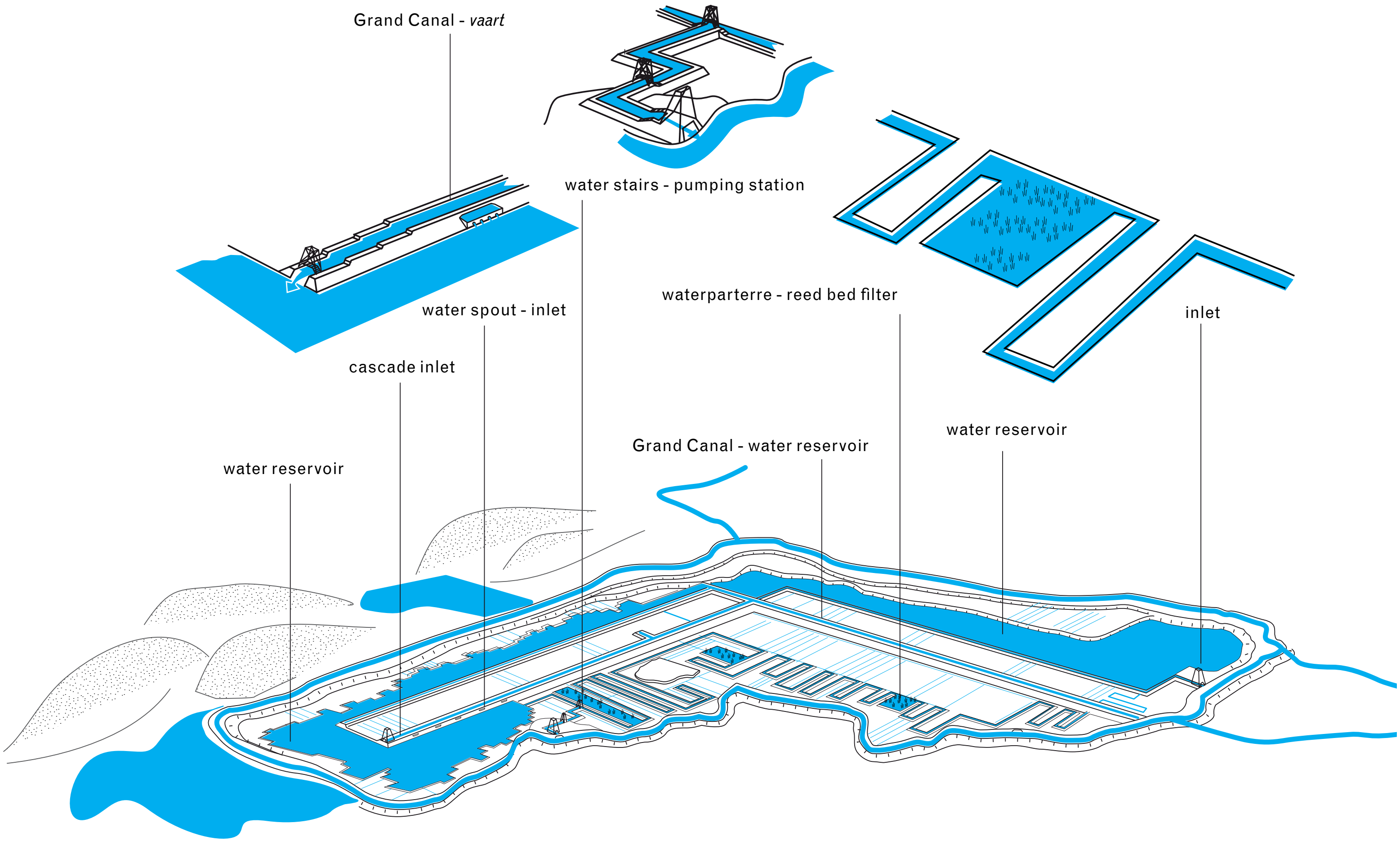
Ford

form: open, channelled body of water
movement: falling and flowing
technical function: dry crossing place

In nature, a shallow place where a river or stream can be crossed is known as a ford. Stepping stones provide access to the island. Because the peatland has little bearing capacity, heavy structures need to be supported by piles. A logical solution is therefore to create floating stepping stones made of a light material.

4 Luijendijk, P., Ottevanger, E., Snoep, K. (2011). Student work MSc 1 Landscape Architecture, TU Delft, Faculty of Architecture

◂ Design by research: Water works and water patterns of the peat polder Ronde Hoep transform into a landscape architectonic composition.


Grand Canal - *vaart*
water stairs - pumping station
waterparterre - reed bed filter
water spout - inlet
inlet
cascade inlet
water reservoir
Grand Canal - water reservoir
water reservoir

The water machine, design-driven research in the Schermer

In the example of the Schermer, a large body of water is sited directly around the polder surface. On the western side of the polder, where the relief of the sand-ridge landscape extends into the edge of the polder, the contours create a rugged, natural water's edge. This rugged edge contrasts with the straight edge of the polder land on the other side of the water. In the design experiment the inside of the hook formed by the polder plan is only partly in use as farmland. Parts of the plots and ditches have been transformed into a reed-bed purification system. The polder water is pumped through the reed beds and is eventually stored in the inner *boezem*. This water machine is made visible by means of landscape-architectonic elements.[5]

5 Chladova, E., Koch, M., Spenkelink, L.. en Paalman, R. (2011). Student work MSc 1 Landscape Architecture, TU Delft, Faculty of Architecture

◂ Design by research: Water works and water patterns of the lake-bed polder Schermer transform into a landscape architectonic composition.

Grand Canal

form: straight, elevated, framed lines of water
movement: still and flowing
technical function: water storage

By inundating parts of the polder, the canals of the former inner *boezem* are disconnected from the dike and the monumental quality of the perpendicular water axes is enhanced. The edge of the canal, formed by the dike, is reflected in the water, so that the element becomes more significant. The enormous length of the water axes reinforces the 'Grand' effect.

Water spout

form: overhanging, channelling water element
movement: falling and flowing
technical function: variable inlet

Along the inner *boezem* dike, water can be let into the polder through spouts. This section of the dike could be replaced by a retaining wall.

Cascade

form: open, channelled line of water
movement: falling and flowing
technical function: inlet

Due to the high elevation of the inner *boezem*, which used to be part of the lake-bed polder drainage system, it is possible to allow clean water to flow gradually downwards. The difference in elevation is articulated by means of a cascade. The change in function, from inner *boezem* to water-storage basins, is made visible.

Water stair (reversed)

form: open, channelled waterwork
movement: flowing upwards
technical function: pump

In the example, the Schermer is transformed into a water-purifying machine. Good water circulation is necessary to achieve this. The water is pumped upwards via water stairs, a modern translation of multi-stage mill configurations. The structures that have been added function as orientation points, landmarks in the polder landscape.

Water parterre

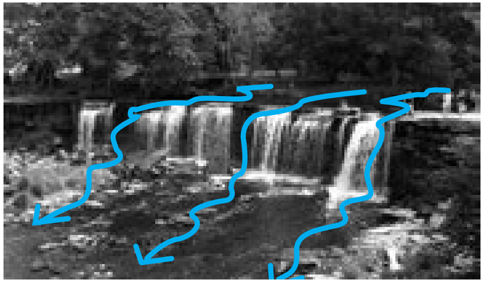
form: geometric body of water
movement: still and flowing
technical function: water-purifying

Large parts of the Schermer have been transformed into a water-purification system using compartmentalised reed beds. The layout of the reed beds makes good use of the different elevations in the lake-bed polder.

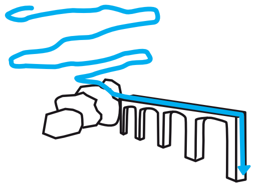
Archetypes

Water elements garden

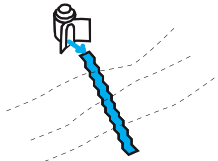
Water elements polder



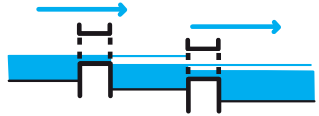
Waterfall



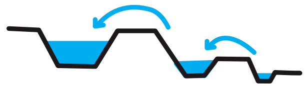
Aquaduct Chatsworth



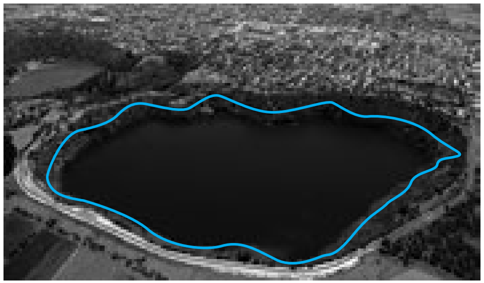
Cascade and Folly Chatsworth



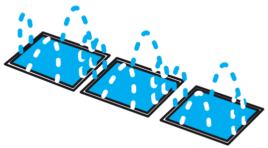
Stepped inlet



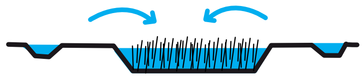
Low *boezem* / Reservoir



Lake

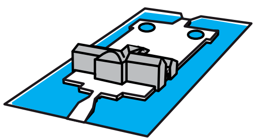


Water parterre and fountains Villa dÉste



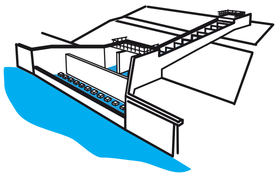
Reed bed filter

Island

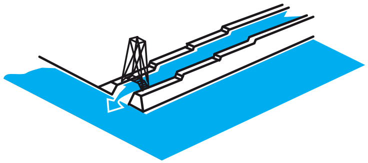


Château island with moat, Vaux le Vicomte

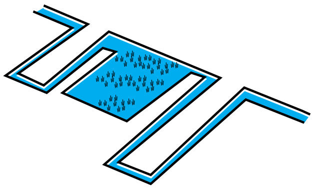
Legakker



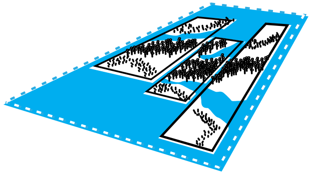
Cascade -Eendrachtspolder



Cascade and landmark - Schermer



Water parterre - reed bed filter Schermer



Water parterre - Eendrachtspolder

We hope that, having read this book, designers and other interested parties will come to regard the water forms, patterns and waterworks in and around polders in a different way, with added 'insight'. The more visible the system and its elements are, the more stimulating it will be to experience and appreciate the coherence of the water design when spending time in or passing through the (urban) landscape. Let us recapture the 'Fine Dutch Tradition', in which utility, solidity and beauty merge in design. We should once again remember that beauty arises when the various adaptations in a design reinforce each other to create a new, coherent mise-en-scene (a readable and comprehensible entity), i.e. a landscape-architectonic composition.[6]

6 Morgan, M. H. (1960). *Vitruvius: The Ten Books on Architecture.* New York

Illustration accountability

Drawings water elements (1, 2 and 3) and photographic work water elements (1, 2 and 3)

COVER

A. v.d. Weide – photo Gemaal Lely, Wieringermeerpolder

01 THE WATER GARDEN AS A SOURCE OF INSPIRATION

Page 8
S. de Wit ▸ photo Beckenstein

Page 10
M. Pouderoijen and J. Wiers ▸ montage on ground surface www.maps.google.nl

Page 11
Bezemer Sellers, V. (2001). *Respublica Hollandiae et Urbes in Courtly Gardens in Holland 1600-1650*. Architectura & Natura

Page 12
Steenbergen, C., Reh, W. (2003). *Architectuur and Landschap*. THOTH ▸ photo 1 (p. 90) and photo 3 (p. 352)
S. Holtappels ▸ photo 2

Page 13
I. Bobbink ▸ drawing

Page 14
S. Loen ▸ adaptation on ground surface: www.maps.google.nl

Page 16
K. Visser ▸ drawing

Page 17
S. Loen ▸ drawing

Villa d'Este

Page 18
Steenbergen, C., Reh, W. (2003). *Architectuur and Landschap.* THOTH drawing Etienne du Perac, 1573 (p. 85) and Pandion (p. 84)

Page 19
S. Loen ▸ drawing

Page 20
S. Loen ▸ drawing
Steenbergen, C., Reh, W. (2003). *Architectuur and Landschap*. THOTH ▸ photo 1 and 2 (p. 89)
www.panoramio.co ▸ photo 3

Page 21
S. Loen ▸ drawing
Steenbergen, C., Reh, W. (2003). *Architectuur and Landschap*. THOTH ▸ photo 1 and 2 (p. 90)
www.panoramio.com ▸ photo 3

Vaux le Vicomte

Page 22
Steenbergen, C., Reh, W. (2003). *Architectuur and Landschap*. THOTH ▸ drawing 1 (p. 140) and photo 1 (p. 136)

Page 23
S. Loen ▸ drawing

Page 24
S. Loen ▸ drawing
S. Holtappels ▸ photo

Page 25
S. Loen ▸ drawing
S. Holtappels ▸ photo 1, 2 and 3

Chatsworth House

Page 26
Steenbergen, C., Reh, W. (2003). *Architectuur and Landschap*. THOTH ▸ drawing (1699) Knyff (p. 349) and photo Pandion (p. 348)

Page 27
S. Loen ▸ drawing

Page 28
S. Loen ▸ drawing
W. Reh ▸ photo 1
www.chatsworth.org ▸ photo 2 and 3

Page 29
S. Loen ▸ drawing
W. Reh ▸ photo 1
www.chatsworth.org ▸ photo 2
www.panoramio.com F. James ▸ photo 3

Page 30 and 31
S. Loen ▸ drawing
unknown ▸ photo 1, 2, 3, 4, 5 and 6

Page 32
impression: landscape architectonic water elements I. Bobbink ▸ photo Borssele and Wilhelmshöhe, Kassel

02 THE NETHERLANDS AND ITS WATER

Page 36
impression: Dutch Heritage Landscapes
Reh, W., et al. (2005). *Zee van Land, de droogmakerij als atlas van de Hollandse landschapsarchitectuur* ▸ photo Pandion (p. 116)
unknown ▸ photo 2, 3, 4
M. Pouderoijen- ▸ photo 5

Page 38
N. Rickert, K. Visser, J. Wiers- ▸ drawing

Page 41
S. Loen ▸ drawing
I. Bobbink ▸ photo 1
unknown ▸ photo 2

Page 42
S. Loen ▸ drawing
M. Pouderoijen- ▸ photo 1
I. Bobbink ▸ photo 2 and 3

Page 43
S. Loen ▸ drawing
unknown ▸ photo 1
I. Bobbink ▸ photo 2 and 3

Page 44
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ drawing 1 (p. 84) - bewerking

Page 45
www.panoramio.com ▸ photo

Page 46
J. Wiers ▸ drawing based on: Waterstaatkundig Informatie Systeem (2001, 4^{e} editie) samengesteld door de Meetkundige Dienst van Rijkswaterstaat. Handleiding Waterstaatkundig Informatie Systeem.

Page 47
J. Wiers ▸ drawing

Page 48
Impression: *boezem-* and polder pumping stations
Reh, W., et al. (2005). *Zee van Land, de droogmakerij als atlas van de Hollandse landschapsarchitectuur-* ▸ photo (p. 224)
M. Pouderoijen ▸ photo 2, 3, 4 and 5

Page 50
J. Wiers and K. Visser ▸ drawing 1 and 2
M. Pouderoijen ▸ drawing

Page 52
J. Wiers ▸ drawing

Page 53
J. Wiers ▸ drawing

Page 54
Map room TU Delft: Topographic map (2009), 1:25.000
Bonnekaart (1894-1925)

Page 55
www.flickr.com - De Jong ▸ photo

Page 56
Kooij, E., Bobbink, I., et al. (2009). *Sterk Water, waterpilot Zuidoostlob.* Waterstaatskaart (1878, 1^{e} editie)
Map room TU Delft: Waterstaatskaart (1984, 3^{e} editie)

Page 58
impression – water problems
unknown ▸ photo 1, 2, 3, 4 and 5

Page 60
Map room TU Delft: Bonnekaart (1888)
Kooij, E., Bobbink, I., et al. (2009). *Sterk Water, waterpilot Zuidoostlob* (p. 42)

Page 62
Bureau H+N+S. (2005). *Pleidooi voor waterrijk handelen.* 2^{e} editie Architectuur Biënnale Rotterdam

Page 63
Bureau H+N+S. (2005). *Pleidooi voor waterrijk handelen.* 2^{e} editie Architectuur Biënnale Rotterdam

Page 64
impression – water landscapes
unknown ▸ photo 1
http://hosper.nl ▸ photo 2
I. Bobbink ▸ photo 3
Atelier de Lyon ▸ photo 4
unknown ▸ photo 5
I. Bobbink ▸ photo 6

03 THE DEVELOPMENT OF THE POLDER LANDSCAPE

Page 68
Franssen, J. (2005). *Het natuurboek: de gebieden van Natuurmonumenten* ▸ photo (p. 194)

Page 70 and 71
S. Loen ▸ drawing

Page 72
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ kaart (p. 17 and p. 84)

Page 73
S. Loen ▸ drawing

Page 74
K. Visser ▸ drawing on ground surface: www.maps.google.nl

Page 75
S. Loen ▸ drawing

Page 76
N. Rickert ▸ drawing 1, 2, 3, and 4
Student work ▸ 3D-model 1 and 2

Page 77
S. Loen ▸ drawing

Page 78
N. Rickert and K. Visser ▸ drawing

Page 80
Vista, Landschapsarchitectuur and Stedenbouw. (2005). *Onderzoek: Functie volgt peil in het Groene hart* - S. Nijhuis ▸ drawing

Page 82
J. Wiers ▸ drawing 1 on ground surface: www.maps.google.nl
K. Visser ▸ drawing 2, 3 and 4 on ground surface: www.maps.google.nl

Page 83
K. Visser ▸ drawing

Page 84
S. Loen ▸ drawing

Page 85
K. Visser ▸ drawing

Page 86
K. Visser ▸ drawing 1, 2, 3 and 4 on ground surface: www.maps.google.nl

Page 87
K. Visser ▸ drawing

Page 88
S. Loen ▸ drawing

Page 89
K. Visser ▸ drawing

04 THE FORM OF THE POLDER WATER

Page 90
impression - pumping-stations
Machinegang pumping station, Atelier de Lyon
Small mill Hoeksche Sluis
Pumping station Alblasserwaard
Mill Alblasserwaard
Pumping station Zuidpolder, Delfgauw
Lower level pumping-station Haarlemmermeerpolder
Pumping station Zuidpolder

Page 91
impression – pumping stations
M. Pouderoijen ▸ photo 1, 2, 5 and 7
Boezem- and storm surge barrier near Krimpen a/d IJssel
Modern pumping station Bentpolder
Flexible dam in peat-river Waver near poldercomplex Ronde Venen

Page 92
I. Bobbink ▸ photo

Page 94
K. Visser ▸ drawing

Page 96
N. Rickert ▸ drawing of waterstructures

Page 98
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ (photo p. 254-55)

Page 99
J. Wiers ▸ drawing

Page 100
Map room TU Delft: Bonnekaart (1920). blad B425 Topografische kaart van Nederland Kadaster (2009). blad 31G and 31E

Page 101
J. Wiers ▸ drawing 1

Page 102
M. Pouderoijen ▸ height map

Page 103
K. Visser ▸ drawing on ground surface from *De Polderatlas* (p. 260)

Page 104
S. Loen ▸ drawing

Page 105
S. Loen ▸ drawing
I. Burger: www.maps.google.nl ▸ photo 1
www.panoramio.com ▸ photo 2
I. Bobbink ▸ photo 3

Page 106
S. Loen ▸ drawing
www.maps.google.nl ▸ photo 1
M. Pouderoijen ▸ photo 2
I. Bobbink ▸ photo 3

Page 107
S. Loen ▸ drawing
I. Bobbink ▸ photo

Page 108
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ (photo p. 214-15)

Page 109
J. Wiers ▸ drawing 1

Page 110
Waterstaatskaart

Page 112
Map room TU Delft: Tresor Delft trl-33,5,08. Anoniem, eind 17de eeuw
Topografische kaart van Nederland (2007). 1:50.000, blad 25 oost and 31 oost

Page 113
M. Pouderoijen ▸ photo
J. Wiers ▸ drawing

Page 114
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ (p. 222)

Page 115
K. Visser ▸ drawing op ondergrond *De Polderatlas* (p. 220)

Page 116
S. Loen ▸ drawing

Page 117
S. Loen ▸ drawing
www.maps.google.nl ▸ photo 1 and 2
I. Bobbink ▸ photo 3

Page 118
S. Loen ▸ drawing
Student work ▸ photo 1 and 3
M. Pouderoijen- ▸ photo 2

Page 119
S. Loen ▸ drawing
Student work ▸ photo 1
M. Pouderoijen ▸ photo 2
www.maps.google.nl ▸ photo 3

Page 120
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ (photo p. 230 and p. 331)

Page 121
J. Wiers ▸ drawing 1

Page 122
Waterstaatskaart

Page 124
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ (kaart p. 252-53)
Tresor Delft trl-11,4,1,01. A. de Vries (1740)
Topografische kaart van Nederland Kadaster (2007). 1:50.000, blad 38 west and 38 oost

Page 125
J. Wiers ▸ drawing

Page 126
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ (hoogtekaart p. 244-45)

Page 127
K. Visser ▸ drawing op ondergrond *De Polderatlas* (p. 242-43)

Page 128
S. Loen ▸ drawing

Page 129
S. Loen ▸ drawing
www.maps.google.nl ▸ photo 1
I. Bobbink ▸ photo 2 and 3

Page 130
S. Loen ▸ drawing
unknown ▸ photo 1
M. Pouderoijen ▸ photo 2
I. Bobbink ▸ photo 3

Page 131
S. Loen ▸ drawing
M. Pouderoijen ▸ photo 1
unknown ▸ photo 2
unknown ▸ photo 2

Page 132
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ (photo p. 354-55)

Page 133
J. Wiers ▸ drawing 1

Page 134
Waterstaatskaarten

Page 136
Map room TU Delft: Claes Claesz Baert. (1635). Regionaal archief Alkmaar inv nr 71.
Topografische kaart van Nederland (2003). 1:50.000, blad 19 west and 19 oost
Page 137
J. Wiers ▸ drawing
Page 138
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ (hoogtekaart p. 362)
Page 139
K. Visser ▸ drawing op ondergrond *De Polderatlas* (p. 360)
Page 140
S. Loen ▸ drawing
Page 141
S. Loen ▸ drawing
www.maps.google.nl ▸ photo 1
Studentenwerk ▸ photo 2 and 3
Page 142
S. Loen ▸ drawing
Student work ▸ photo
Page 143
S. Loen ▸ drawing
www.bing.com/maps ▸ photo 1
unknown ▸ photo 2
Student work ▸ photo 3
Page 144
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ (photo p. 400-01)
Page 145
J. Wiers ▸ drawing
Page 146
Map room TU Delft: B. de Vries (1858) Utrechts archief ta, 169-3.
Topografische kaart van Nederland (2009). 1:50.000, blad 31 oost
Page 147
J. Wiers ▸ drawing
Page 148
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ (height map p. 410)
Page 149
K. Visser ▸ drawing on ground surface *De Polderatlas* (p. 408)
Page 150
S. Loen ▸ drawing
Page 151
S. Loen ▸ drawing
www.maps.google.nl ▸ photo 1
I. Bobbink ▸ photo 2 and 3
Page 152
S. Loen ▸ drawing
I. Bobbink ▸ photo 1
M. Pouderoijen ▸ photo 2
www.maps.google.nl ▸ photo 3
Page 153
S. Loen ▸ drawing
M. Pouderoijen ▸ photo 1 and 2
www.maps.google.nl ▸ photo 3
Page 154
Steenbergen, C., Reh, W., et al. (2009). *De Polderatlas van Nederland.* THOTH ▸ (photo p. 430-31)
Page 155
J. Wiers ▸ drawing
Page 156
Map room TU Delft: Pouderoyen, C. (1943). Landschap-sontwerp Nieuw Land. Archief Rijksdienst voor de IJsselmeerpolders.
Topografische kaart van Nederland Kadaster (2003). 1:50.000, blad 15 oost, 16 west, 20 oost and 21 west
Page 158
M. Pouderoijen ▸ drawing
Page 159
K. Visser ▸ drawing op ondergrond: *De Polderatlas* (hoogtekaart p. 440)
Page 160
S. Loen ▸ drawing
Page 161
S. Loen ▸ drawing
www.maps.google.nl ▸ photo 1 and 3
M. Pouderoijen ▸ photo 2
Page 162
S. Loen ▸ drawing
www.maps.google.nl ▸ photo 1 and 2
M. Pouderoijen ▸ photo 3
Page 163
S. Loen ▸ drawing
www.maps.google.nl ▸ photo 1
M. Pouderoijen ▸ photo 2 and 3
Page 164
S. Loen ▸ drawing
www.maps.google.nl ▸ photo 1 and 3
M. Pouderoijen ▸ photo 2
Page 165
S. Loen ▸ drawing
www.maps.google.nl ▸ photo 1 and 2
M. Pouderoijen ▸ photo 3
Page 166
impression - Dikes and Embankment
Page 168
impression - Water lines
I.Bobbink ▸ photo 1,2,3 and 4
M. Pouderoijen ▸ photo 5 and 6
Page 170
www.delyon.nl/ - Sisyfusgemaal. Atelier Lyon ▸ photo
Page 172
B. Kwast and N. Rickert ▸ drawing
Page 174
B. Kwast and N. Rickert ▸ drawing
Page 176
B. Kwast and N. Rickert ▸ drawing
Page 178
Map room TU Delft: Topografische kaart van Nederland (2009). blad 38A and 37F
Page 179
J. Wiers ▸ drawing
Page 180
K. Visser ▸ drawing
Page 182
K. Visser ▸ drawing on ground surface S. Nijhuis
Page 183
S. Loen and K. Visser ▸ drawing
Page 184
S. Loen ▸ drawing
I. Bobbink ▸ photo 1 and 2
Copijn tuin- and landschapsarchitecten ▸ drawing 3
Page 184
S. Loen ▸ drawing
Copijn tuin- and landschapsarchitecten

▸ photo 1 and 2
http://guidovanderwedden.ning.com/ ▸ photo 3

Page 186
Map room TU Delft: Topografische kaart van Nederland (2009). blad 11D
www.maps.google.nl

Page 187
J. Wiers ▸ drawing

Page 188
K. Visser ▸ drawing

Page 190
K. Visser ▸ drawing on subsoil Nijhuis S.

Page 191
S. Loen ▸ drawing

Page 192
S. Loen ▸ drawing
www.museumbelvedere.nl ▸ photo 1, 2 and 3

Page 193
S. Loen ▸ drawing
www.clusiusstichting.nl ▸ photo 1
www.museumbelvedere.nl ▸ photo 2 and 3

Page 194
Map room TU Delft: Topografische kaart van Nederland (2009). 1:25.000
www.maps.google.nl

Page 195
J. Wiers ▸ drawing

Page 196
K. Visser ▸ drawing

Page 198
K. Visser drawing on subsoil S. Nijhuis

Page 199
S. Loen ▸ drawing

Page 200
S. Loen ▸ drawing
Atelier Veldwerk ▸ photo 1 and 3
M. Pouderoijen ▸ photo 2

Page 201
S. Loen ▸ drawing
Atelier Veldwerk ▸ photo 1, 2 and 3

Page 202
Map room TU Delft: Topografische kaart van Nederland (2009). 1:25.000
www.maps.google.nl

Page 203
J. Wiers ▸ drawing

Page 204
F. Toni ▸ drawing

Page 206
F. Toni and K. Visser ▸ drawing op ondergrond S. Nijhuis

Page 207
F. Toni ▸ drawing

Page 208
F. Toni and S. Loen ▸ drawing
F. Toni ▸ photo 1 and 2
A. v.d. Weide ▸ photo 3

Page 209
F. Toni and S. Loen ▸ drawing
F. Toni ▸ photo 1, 2 and 3

Page 210
impression – water lines
Designers of the project ▸ photo 1,2,3,4 and 5

Page 212
Minjie Si ▸ design

06 PERSPECTIVE AND CONCLUSION

Page 214
In the educational program of the Landscape Architecture department, students work on many different assignments in the polder landscape. By an invitation of 'Waternet' (the water board of Amsterdam) students were ask to research and design possible solutions for water retention in the public space of Southeast- Amsterdam.
In the park design water becomes the carrier of the spatial experience, different amounts of water define different routes through the park.
Under the infrastructural junction space is wasted. A new design of water basins, with different water levels organizes the place and scales it down to a human size. The sound of falling water overlays the noise of highway and train track.
Parts of the neighborhood can be flooded if new housing types are introduced. The image illustrates a house, which can move vertically along pools.
Along the peat river Amstel polders can be transformed into retention areas. A new diagonal situated canal regulates the water flow.

Page 216
S. Loen ▸ drawing based on experiment Ronde Hoep

Page 218
S. Loen ▸ drawing based on experiment Ronde Hoep

Page 220
S. Loen ▸ drawing based on experiment Schermer

Page 222
S.Loen and K. Visser ▸ drawings

Page 223
S. Loen and K. Visser ▸ all drawings

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06 PERSPECTIVE AND CONCLUSION

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Water terms in alphabetical order – more than 100 words inSight!

The numbers refer to the page on which the term is explained:
by text and/or by drawing and/or by photograph.

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Notes

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Water inSight provides insight into the 'water machine' that forms the basis of the Dutch polder landscape. Authors Inge Bobbink and Suzanne Loen approach the polder landscape from a landscape-architectonic point of view, using technical and spatial analysis drawings, images, plans and experiments to visualise the Netherlands and its water system.

Special attention has been paid to polder water, the difference between a peat polder and a lake-bed polder, and the adaptations that are required in the face of climate change. Analyses of the Eendragtspolder, the Belvedère museum, Wickelhof Park and the Onnerpolder pumping station show the diversity of the Dutch water machine and its potential landscape-architectonic qualities.

Water inSight is an accessible book for everyone who has a desire to understand the Dutch polder landscape and to be able to recognise the workings of the water machine and adapt it in a landscape-architectonic design. The book contains practical applications and is aimed at water design and management professionals, landscape architects and landscape managers.

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