The New Dutch Waterline

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Abstract

The Dutch are well known for their defensive use of water on a large scale. The best known example of this is the New Dutch Waterline. This article describes the working of the waterline and its history and evolution throughout the nineteenth century. This evolution is constantly placed against the background of the political and technological changes of that era. Some of the critiques that have been expressed throughout the years on the effectiveness of the defence system are treated here as well. The many illustrations that accompany the text show the various fortifications that can be found within the defence system.

Keywords: Defence lines, nineteenth century fortifications, New Dutch Waterline, World Heritage

The Dutch situation, geography and economy

The Dutch are well known for their use of water as a means of defence. Of course, the defensive use of water is not restricted to the Netherlands alone. Around many fortified towns in France, for example, inundations were used to strengthen the defence: Calais, Le Quesnoy, Verdun and Strasbourg just to name a few. Even Luxembourg, situated in a mountainous area, had systems of sluices to block the rivers and inundate parts of the valley that crosses the town. In all these cases, the differences in height of the surrounding landscape limited the inundations to relatively small areas. It was the geographical condition of the Dutch land that made large-scale inundations possible. The country was crossed by many rivers, and the landscape dotted with lakes and marshes. Large parts of the land were flat and located below the water level of the rivers and the sea. Over the centuries, by building dikes and reclaiming land, even more of this flat, lowland was created. It could easily be flooded, this led to the creation of defence systems relying on large-scale inundations: waterlines.

It wasn't just the geography of the land that made the use of waterlines such a success in the Netherlands. It was the political and economic situation as well: the part of the country that could most easily be protected by inundations

Figure 1. Location map.

was the most important: the province of Holland. Here the most important economic and political centres were located: Amsterdam, Den Haag, Dordrecht, Leiden, Alkmaar, Haarlem, etc. Without conquering the west of the country, it was almost impossible to conquer the whole of the Netherlands. The concentration of political and economic power in Holland, combined with the possibility of creating large-scale inundations to protect it, has been the backbone of the Dutch national defence for centuries.

The idea behind a waterline

The idea behind a waterline is simple: by flooding a large area of land an unbridgeable barrier is created that will stop an enemy invasion. However, creating such a water barrier, with the right depth and size, is more complicated than it sounds.

First of all, in order to be able to flood the land it is necessary to have a network of sluices and waterways (canals, rivers, ditches etc.) to get the right amount of water, at the right speed to the area that needs to be flooded.

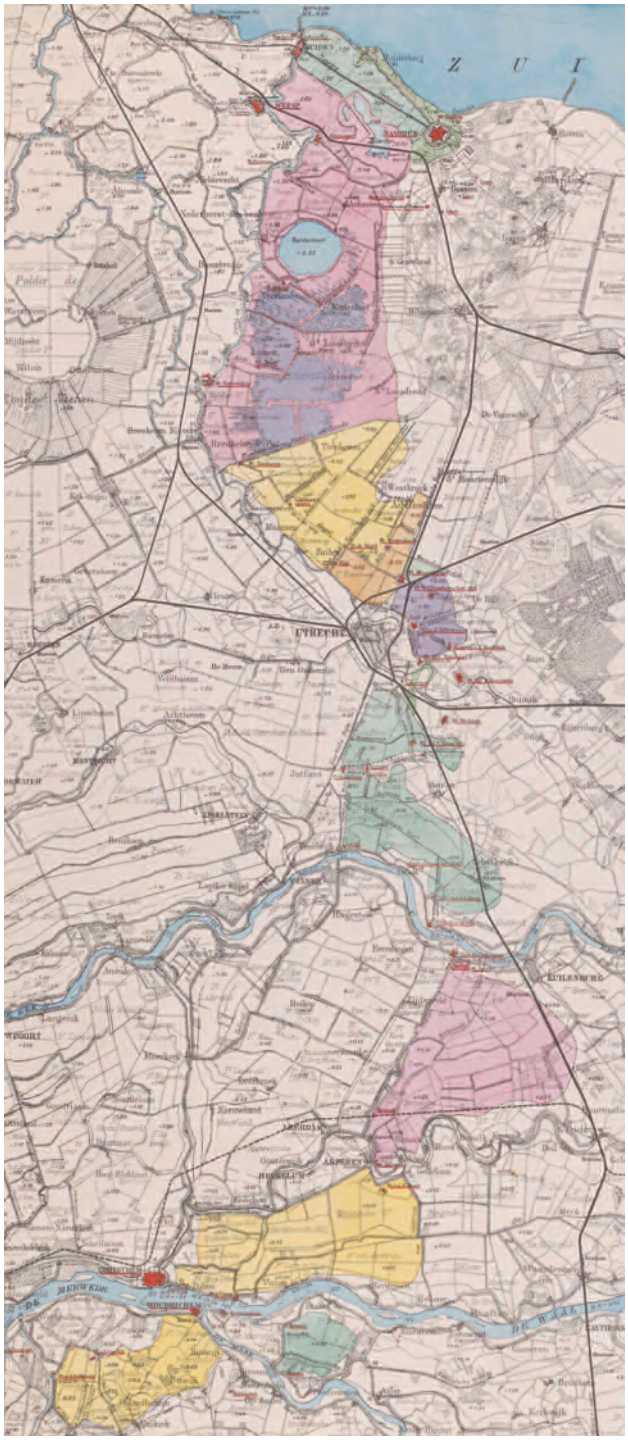


Figure 2. Map with an overview if the NDW. The defence line stretches from Naarden and Muiden, on the bord of the IJssellake, in the north, to Gorinchem and the lands between the great rivers in the south. The total length of the defence line is 85 kilometres, and the inundations occupy over 40.000 hectares. The accesses are defended by 60 forts and 5 fortified cities. This map shows the waterline in 1885. Each colour represents an inundation basin. In the middle of the defence line, it is clearly visible that parts of the land around Utrecht could not, or hardly, be flooded.

Secondly, the land can't be randomly flooded. If the water plain gets too deep, the invading army can sail across it. If it is too shallow, soldiers can wade through it to the other side. A depth of about 50 centimetres (knee-deep) is the best.[1] To reach the right depth in every part of the waterline, the countryside must be divided in different sections. These sections are called inundation basins. The height of the ground level is relatively constant within each individual basin.[2] That way in every one of the basins the optimal water level can be reached and the differences in height between the various parts of the land are compensated. Besides that, it saves inundation time and limits the amount of water that needs to be moved. The basins are separated from one another by dikes and each basin is fed with water individually.

Because the water plain is relatively shallow, there are always parts of land that will remain dry: natural heights, dikes and (rail)roads. These dry areas can form a passage through the waterline.[3] Such a passage is called an access, and an access is closed by a fort. Rivers and canals form accesses as well. After all, their depth makes it possible for an enemy to sail through the water barrier. These accesses are closed by the crossfire of forts build on the riverbanks. In some cases, the forts are supported by cannon boats on the river.

To summarize: a waterline consists of a network of waterways and sluices that feeds a series of individual inundation basins, separated by dikes. The water in each basin has depth of about 50 cm. Passages through this water plain, called accesses, are closed by fortifications. A waterline makes it possible for a relatively small army to control a large area of land. The water does most of the work. The army only has to focus on the accesses.

Developments in the sixteenth and seventeenth centuries

Before looking at the history of the New Dutch Waterline

Figure 3. Detail of the map of Figure 1, showing a typical access situation, just south of Utrecht. A higher stretch of land with a road running over it can't be inundated. It forms an access, and it is closed by a fort (Fort Jutphaas) and two batteries.

Figure 4. Aerial view of Fort Jutphaas today. The fort still exists but it is completely absorbed by modern urban structures.

in more detail, it is interesting to have a short overview of the developments leading up to the creation of this famous defence line. The first use of large-scale inundations in Dutch warfare date from the Eighty Years War (1568-1648). During that war inundations were used as a means of offence: forcing the lifting of a siege by flooding the land, and as a means of defence: preventing a siege by flooding the land. A famous feat of arms in this respect is the siege of 's Hertogenbosch by the army of Stadholder Frederik Hendrik in 1629. The city was in Spanish hands and protected by marshes, rivers, and inundations. By equipping the contravallation line with polder-mills, the Stadholder managed to drain the large marshy area around the city. This opened the weaker parts of the city's defence to an attack and eventually led to its conquest. To prevent Spanish relief forces from reaching the city, the Stadholder used the water he pumped away as a defensive inundation around his own circumvallation line. This spectacular siege became famous throughout Europe.

That same year Frederik Hendrik also had the land between Muiden, Utrecht and Vreeswijk flooded. With this he put a plan into motion that had been conceived forty years earlier, in 1589. It remained a one-time occasion but the first step towards the creation of a waterline had been taken. The second step followed in 1672. That year the Dutch Republic was invaded by the French. Without meeting much resistance, the French forces occupied the east of the Republic and took the

Figure 5. Detail of the map of figure 1, showing a river-access. Several waterways meet each other here. They are defended by the crossfire between the two fortified cities Woudrinchem and Gorinchem and that between Fort Vuren and castle Loevenstein. The latter is one of the two medieval castles that are part of the NDW (the other is the castle of Muiden).

strategic cities of Utrecht and Naarden. With this last conquest the road towards Amsterdam was wide open were it not for the fact that the Dutch had flooded the land between Muiden, to the north, and Gorinchem to the south, all the way between the rivers Rhine, Waal, and Meuse into Brabant. The inundations were made in a hasty, improvised way, but they were effective. Between Amsterdam and Muiden lay a water plain kilometres wide. This water barrier proved impenetrable for the French and a year later they were forced to evacuate the Dutch Republic. That same year the decision was made to turn these improvised inundations into a professional, controllable defence system. This led to the construction of what we now know as the Old Dutch Waterline. Over the years, this defence system was adjusted and modernized, until in the early nineteenth century, it was replaced by a new waterline located more to the east of the country. It included the strategic city of Utrecht. This waterline is known today as the New Dutch Waterline (NDW).

Figure 6. Aerial view of that same river access. On the foreground Fort Vuren. In the background, on the other side of the river, castle Loevenstein.

Figure 7. Aerial view of Fort Spion today. Here the whole idea behind the waterline is visible immediately.

Figure 8. Promotional photo from the 1930's, showing the effect of the inundations.

Figure 9. Most of the land that was to be inundated was farmland. Inundations had a devastating effect on land and crops. Especially when salt water was used. So, farmers were mostly against inundations and didn't hesitate to sabotage them if need be. There are many examples of such sabotage from 1672. Symbolic for this is the townhouse of Nieuwpoort. It was built after the French invasion, as part of the Old Dutch Waterline. The inundation sluice is located underneath the building. Where it could be guarded and kept safe from attempts of sabotage. It wasn't until 1896 that financial compensation for inundation damage was organized by law.

Figure 10. The Old Dutch Waterline from 1672. Utrecht is lying outside the inundated area on the east side.

Figure 1.1 Baron Cornelis Kraijenhoff (1758-1840) is the most important Dutch military engineer of the nineteenth century. He was an all-round scientist. He studied philosophy and medicine and did physics experiments in his spare time. In 1782 he introduced the lightning rod in the Netherlands. Besides all that, he kept an interest in military engineering, the trade of his father who taught him the basic principles. During the military unrest of the 1790's he established himself as a military engineer and in the years that followed, he got a key-role in the design of the Dutch national defence. He kept this role under the rule of Napoleon and was named Inspector General of Fortifications in 1815 by King Willem I, who ennobled him with the title of baron that same year. Kraijenhoff designed the trace of the New Dutch Waterline in 1796 and started carrying out works on this defence line from 1815 onwards. Besides that, he was responsible for the work on the Wellington Barrier and the design of various fortifications around Amsterdam after the British attack on Holland in 1799. He has left an important mark on the Dutch national defence.

Figure 13. One of the fan-sluices at Fort Asperen in opened position.

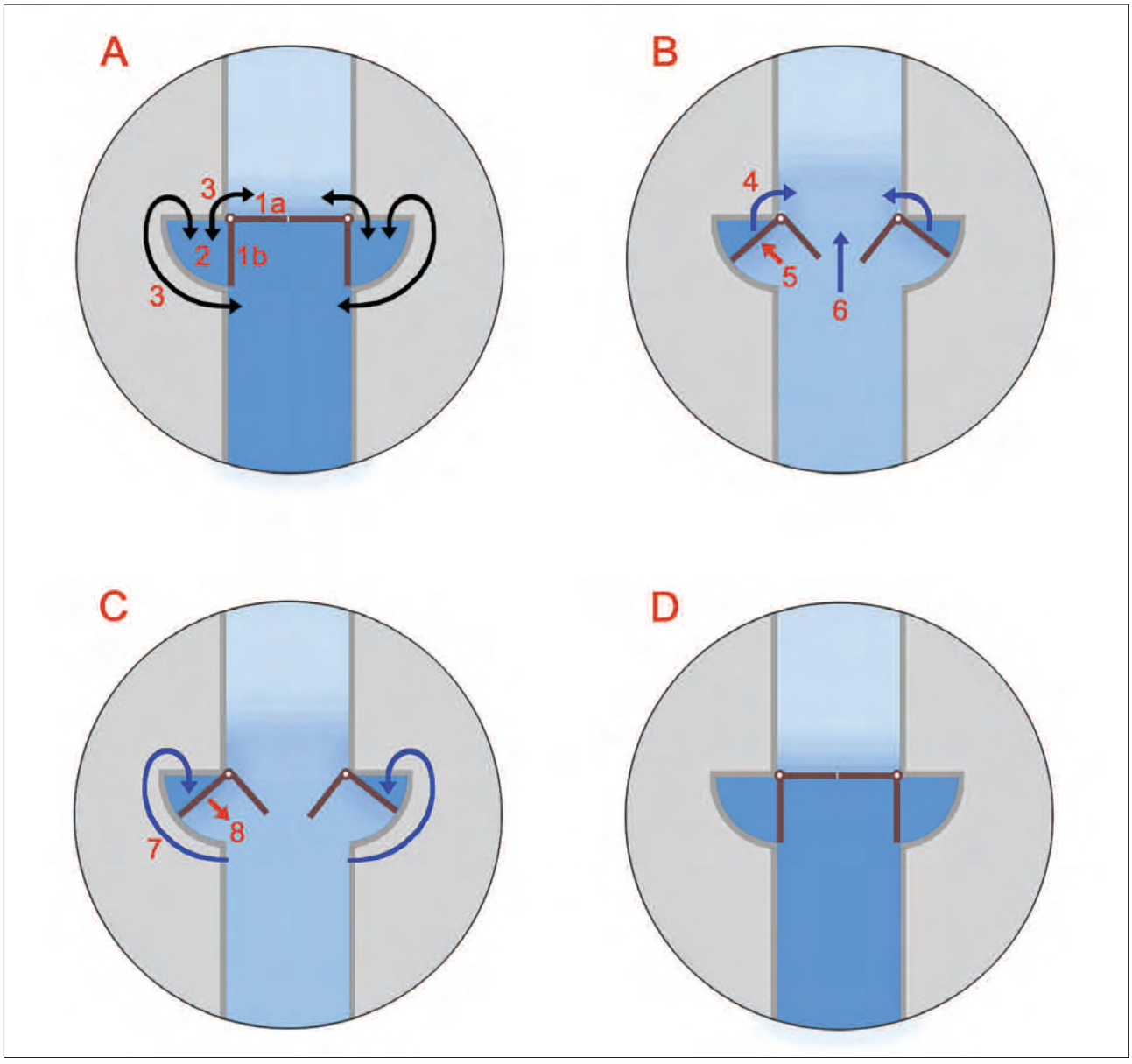


Figure 12. During the first building stage of the NDW, many new sluices were built. Many of those were of a special kind: the fan-sluice, a Dutch invention from the end of the 18th century. Its name is derived from the shape of the doors that remind of a fan. It is a sluice that can be turned against high water and the streaming direction of the water, thanks to the shape of the door. This works as follows:

Picture A: the sluice-doors have an L-shape, consisting of two connected parts. Part 1b is 20 percent bigger than part 1a. Part 1a forms the actual sluice-door, part 1b can turn into a separate chamber in the quay of the sluice: indicated with number 2.

This chamber can be filled of emptied through two channels, indicated with number 3. They relate to the water on both sides of the sluice door.

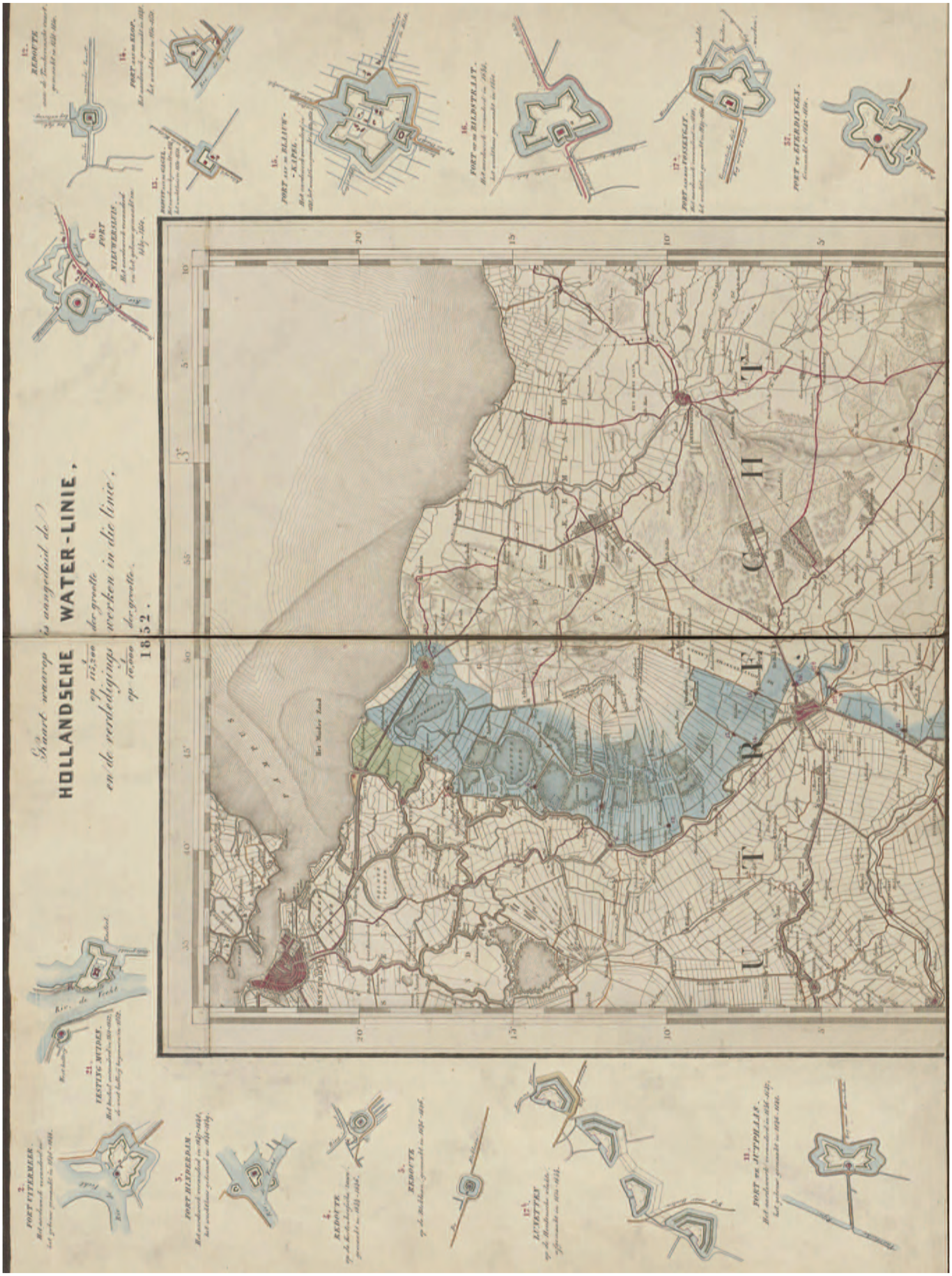
Light blue indicates the low water, dark blue the high water.

In this situation the water in the chamber is high and the water pressure on door 1b the same on both sides. Both channels (3) are closed.

Picture B: by opening the channel connected to the low water (4) the chamber (2) is drained. The water pressure on the outside of door-part 1b rises and is bigger than the pressure on door-part 1a, because of the difference in size of the two door-parts. This difference in pressure causes door-part 1b to turn into the chamber (5): the sluice opens against the high water and the inundation water streams into the land (6).

Picture C: when the doors need to be closed again the channel 4 is closed and the channel connected to the high water is opened (7). The chamber fills again turning the process of the difference in pressure on the door-parts around. The door is closed again.

Picture D showed the closed situation again.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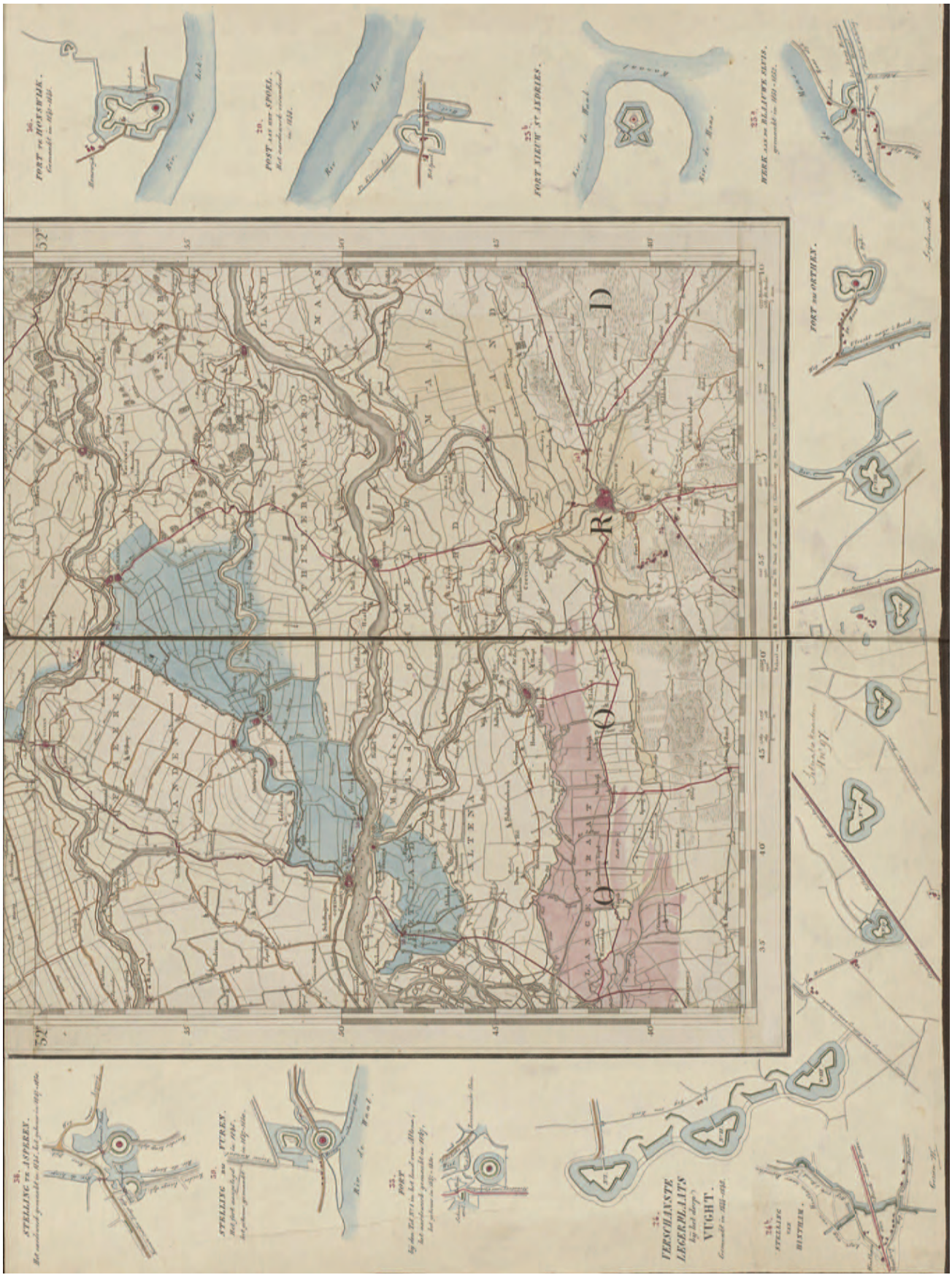


Figure 14. Overview of the NDW in 1850. There are drawings of various fortifications in the margin of this map.

Figure 15. Detail of that same map, showing the first fortification ring around Utrecht. The ring consists of 5 forts (marked as 13-17a on the drawing) and four demi-lunes (17b on the drawing): Fort De Gagel, Fort aan De Klop, Fort Blauwkapel, Fort op de Biltstraat, Fort Vossegat and the four demi-lunes protecting the Houtense Vlakte.

The nineteenth century, an age of progress

Work on the NDW started in 1815 and lasted until just before the Second World War. During this 125-year period the waterline and its fortifications were constantly adjusted and modernized. The largest part of this construction period falls in the nineteenth century, a time of drastic technological changes. Things that were considered modern one day could be outdated the next. This had a great impact on fortifications. Over the period of 1815-1915, fortified cities, such as Naarden, became obsolete and were replaced by complexes of detached forts. This was followed by a transition to networks of trenches, shelters, and gun positions. Tanks took the role of moving forts. The coming of trains and telegraphs changed transport and communication rapidly. New canals were being dug to facilitate bulk transport over water. The European infrastructure was drastically modernized in a short period of time. Besides all these technological changes, there were political changes as well. In the Netherlands themselves, but also in the rest of Europe. The development of the NDW must be seen against this

Figure 16. Aerial view of two of the four demi-lunes protecting the Houtense Vlakte in their situation today.

Figure 17. One of the demi-lunes seen from street level in 2016.

Figure 18. Detail from the margin of the map of 1850 showing the Fort op de Biltstraat. It has a traditional bastioned trace with earthen walls. Here it is clearly visible that the fort lies in the axis of the road that forms the access through the inundation, thus controlling it completely. The Reduit at the back of the fort, shown in red on the drawing, was added in 1850. Before that, the Reduit was only an earthwork.

dynamic background. In that way, the history of the NDW is not only the history of a single defence line, but also the history of the Dutch national defence. The building history of the NDW can be divided into six different stages. In the following text each stage is described against its specific political and technological background.

Napoleon and King William I, the first building stage

In 1815, after Napoleon's defeat at Waterloo, the Kingdom of the Netherlands was founded. It was a large state, bordering northern France. It included the current Netherlands, Belgium, and Luxembourg. The main function of this new state was to keep future French aggression in check. For this purpose, the Wellington Barrier was created: a defence line of fortified cities along the northern border of France. It included the impressive citadels of Huy, Dinant and Namur. The lion's share of the Dutch defence budget was spent on these fortifications. Therefore, not many activities took place in the development of the rest of the national defence. There is

Figure 19. Aerial view of the Fort op de Biltstraat from the 1930's.

one exception: in 1815 king William I of the Netherlands gave his inspector-general of fortifications, Cornelis Kraijenhoff, the order to start working on the NDW. It is interesting to note that Kraijenhoff had already developed plans for the NDW at the end of the eighteenth century and that Napoleon, in October 1811, had given him the order to start working on this new waterline. Due to the developments elsewhere in Europe (the Peninsular War, the Russian Expedition, and the Battle of Leipzig) these

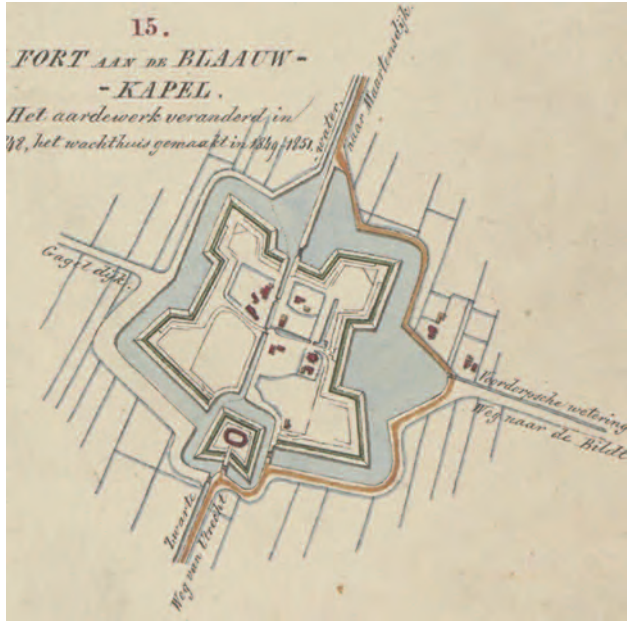


Figure 20. Similar detail from the map of 1850, showing Fort Blauwkapel. Its construction is similar to that of Fort op de Biltstraat. This fort is an interesting case. Originally Blauwkapel was a small hamlet. It was completely integrated into the fort in the 1820's. This makes Fort Blauwkapel a tiny, fortified town.

Figure 2.1 The sixteenth century church in Fort Blauwkapel today.

Figure 22. Originally the Reduit of Fort Blauwkapel consisted only of earthworks. In 1850, this bombproof building was added to the Reduit. During the fourth building stage of the waterline, the earthen wall around the building was heightened and strengthened and the roof of the building was covered in a thick layer of earth. The earthworks were restructured during restauration campaigns after WWII, giving the building its current appearance.

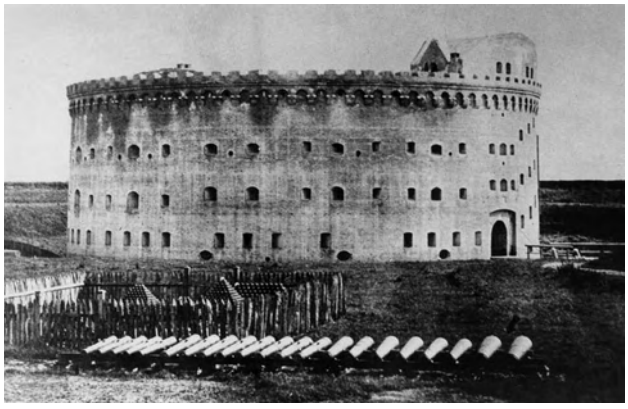


Figure 23. The Tower Fort of Honswijk in the middle of the nineteenth century, before it was modernized during the fourth building stage.

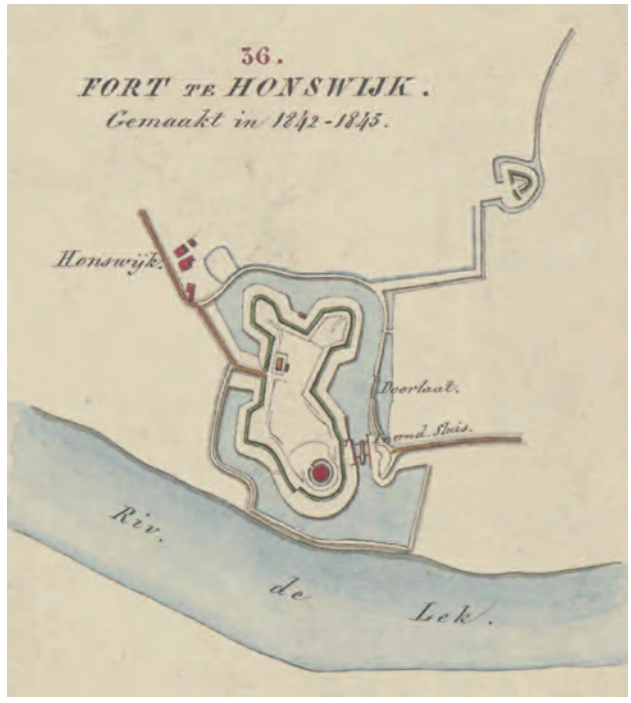


Figure 24. Detail from the map of 1850, showing Fort Honswijk. The tower fort has its own ditch and drawbridge. On the east-side of the fort lies the inundation sluice. To the north-east lies the Lunet aan de Snel, a small, detached earthwork.

Figure 25. The interior of the tower of Honswijk

Figure 26. Fort de Gagel in 2016. The small, square, tower at the centre of the picture was built in 1850. Back then, the fort consisted of a simple earth wall, enclosing an almost square space. It was surrounded by a ditch. The small tower stood in the centre of the enclosure. The large barrack building behind it (on the left side) dates from 1879, the fourth building stage. It protected the small tower from direct fire with modern rifled artillery. It was therefore unnecessary to cover the tower with earth.

Figure 28. The Westbatterij in 2016

Figure 27. Aerial view of the mouth of the Vecht-river in Muiden. In the foreground the tower fort of Muiden, called the Westbatterij. It was built in 1850. This tower wasn't modernized during the fourth building stage. In the background the castle of Muiden. The second medieval castle in the NDW.

plans never came further than the drawing board. In 1815 they were revived by the Dutch king and work was started right away.

This first building stage of the waterline (1815-1828) consisted of two parts. The first was the construction of new sluices, to improve the inundations. All these sluices were defended by small fortifications (batteries). The second was the construction of a ring of fortifications east of Utrecht, the new addition to the waterline. Because of the city's central position in the country many roads led to the town, creating just as many accesses through the waterline. Besides that, parts of the land on the east side of Utrecht could not, or hardly, be inundated. To close all these accesses, it was necessary to create a ring of detached fortifications around the city. All these fortresses were simple, bastioned constructions, entirely made of earth, except for a series of four demi-lunes protecting the large access known as the Houtense Vlakte (= the Plain of Houten). Because of their strategic and exposed position, they were constructed in brick. Together, these four demi-lunes blocked the broad access over the Houtense Vlakte. They lay in each other's field of fire, thus creating a completely closed barrier, without obstructing the possibility for a defending army to make sorties through the spaces between them. These works were finished around 1828.

The Netherlands reduced, the second building stage

Not long after that, in 1830, the kingdom of the Netherlands fell apart. The Belgians revolted and declared themselves independent. This resulted in a short war that ended after ten days, due to pressure from England and France. The independence of Belgium was recognized by the European powers, under the condition that the state remained neutral. It was unacceptable for the Dutch king, and it took him until 1839 to finally accept the loss of Belgium and sign the Treaty of London, that ratified the situation.

An important consequence of the loss of Belgium was that the Netherlands were reduced to a small state with

Figure 29. To facilitate the inundations, this hollow batardeau with three sluices was constructed at the castle of Muiden in 1851. It is a unique construction in the NDW, derived from the hollow batardeaux build in Veere and Vlissingen in 1811, during the Napoleonic era. There used to be a hollow batardeau in Gorinchem as well, dating from 1819, but it was demolished at the end of the 19th century.

relatively long borders. A territory that was hard to defend with the little means in men and material that this small state had. It gave rise to the discussion whether the Dutch government should choose for a concentrated defence or not. In such a defence-scenario, only the west of the country (the economically and politically vital province of Holland) would be protected by waterlines and fortifications. Fortifications in the rest of the country were to be demolished. This territory would only be defended by a field army that could retreat behind the defence line around Holland if need be. From there the army could defend the nation further, while waiting for an allied nation

Figure 30. The interior of the hollow batardeau. The sluices can still be used and have been modernized. On the landside, the batardeau is equipped with embrasures for muskets to defend the inside of the ditch.

to come to their aid. This discussion wasn't concluded until thirty years later and was always present in the background when decisions about the national defence had to be made. Regardless of this discussion, the Dutch government took the decision to become a neutral state. It is important to notice that neutrality is something that needs to be upheld. Although a state doesn't get actively involved in conflicts it is still obliged to protect itself from being attacked or occupied by another state. So, a strong national defence is still needed. Therefore, the role of the NDW became more prominent in the Dutch national defence. In fact, the NDW became the most important line of defence, and this led to more building activity. It is the second building stage of the waterline (1840-1865).

During this period, existing forts were modernized. Earthworks were changed and bombproof, brick buildings were added. These buildings were not yet covered with the thick layers of earth, as was done in the late nineteenth century. They were freestanding brick constructions. The buildings were used as barracks and storage rooms and could function as a last retreat during a siege. In most cases they were surrounded by a ditch and artillery

Figure 31. Detail of the map from 1885, showing the ring of forts around Naarden. 1a marks the two earthworks from 1868. 1b marks Fort IV, from 1868, that still exists today. With the 2, the two batteries are marked that were added around 1878.

platforms were installed on their roofs. Not only the newly build forts from the first building stage (1815-1828) were updated. Forts that used to belong to the Old Dutch Waterline, and were, in 1815, integrated into the new one, were modernized as well.

Also, many new forts were built during this period. They got the same structure as the modernized, existing forts: earth walls, surrounded by a wet ditch with a freestanding brick building in it. The small versions of these buildings were square and inspired on the Tour Modèle from the Napoleonic era. The large versions were circular, casemated constructions. Some of them huge and several

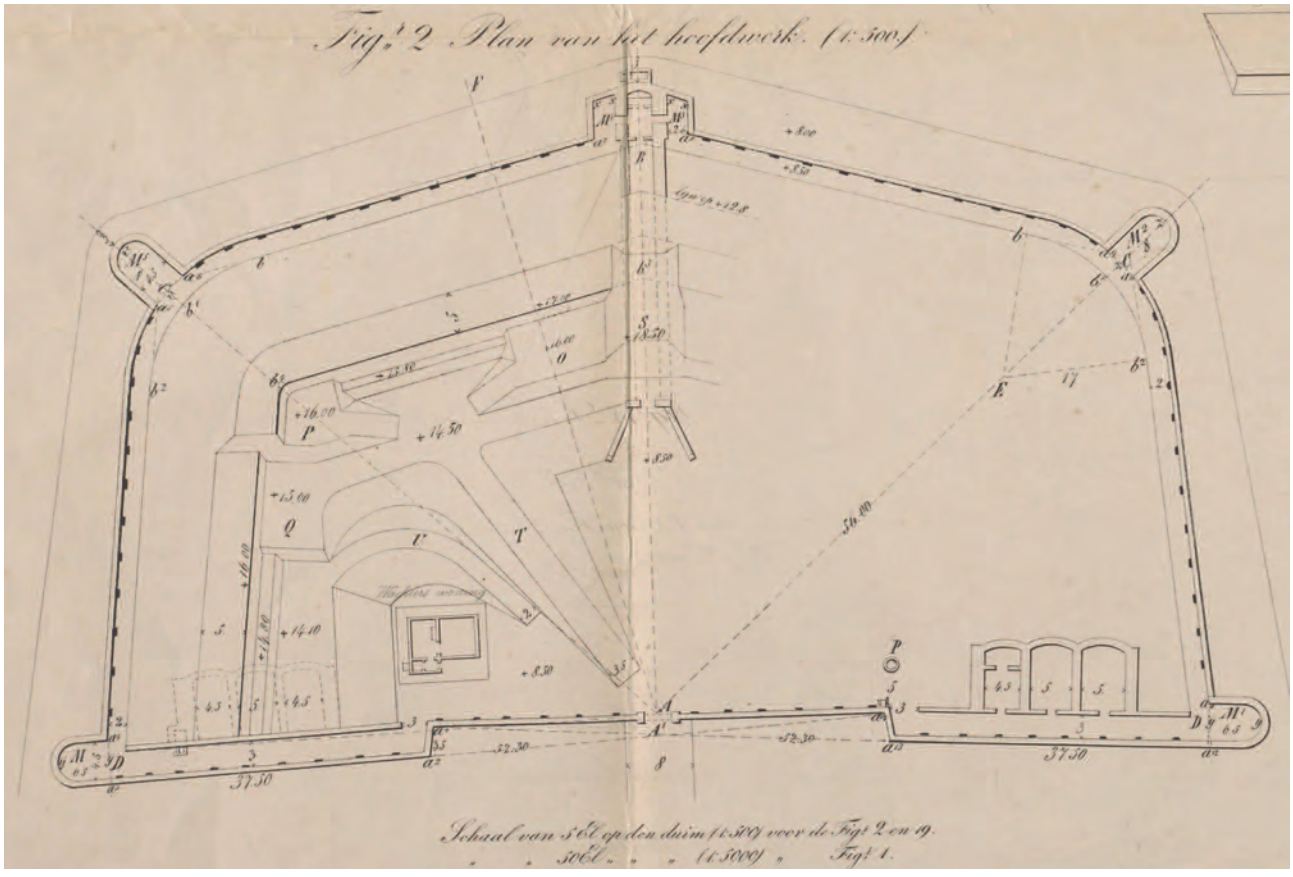


Figure 32. Drawing of Fort IV, floorplan from 1868.

Figure 33. The freestanding wall in the dry ditch and caponnieres of Fort IV, in 2016. In case of an attack the caponnieres were made bombproof with a removable roof construction.

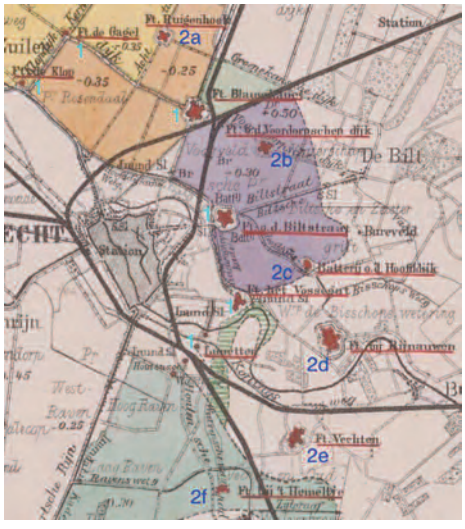


Figure 34. Detail from the drawing of 1885, showing the fortifications around Utrecht. With 1, the forts of the first fortification ring are marked (see fig. 12). With the 2, the forts of the second ring are marked. 2a: Fort op de Ruigenhoekse Dijk, 2b: Fort op de Voordorpse Dijk, 2c: Batterij op de Hoofddijk, 2d: Fort Rijnauwen, 2e: Fort Vechten, 2f: Fort 't Hemeltje.The thick black lines mark the railroads. Here it is clearly visible that Fort Blauwkapel (part of the first fortification ring) defends an important crossing of railroads. It gave the fort an important position in the second ring as well.

storeys high, with a medieval inspired architecture. The best-known tower of this type is in Fort Honswijk, along the river Lek (part of the Rhine). Its pendant was Fort Everdingen located on the other bank of that river. These towers were inspired by the Maximillian towers in Linz, Austria. The towers caused controversy almost as soon as they were built. The large freestanding constructions were considered too conspicuous and too easy a target for an invading enemy. Nonetheless, ten of these towers were built.[4] Most of them along the river accesses. The towers of Honswijk and Everdingen are the oldest and the largest of them, constructed between 1841 and 1848.

Rifled artillery, the third building stage

Around 1860, rifled artillery was introduced in European warfare. Guns equipped with these new gun barrels were

Figure 35. Aerial view of fort Rijnauwen in the 1930's. Here it is clearly visible that the design of the fort was inspired on the Brialmont forts of Antwerp.

able to fire with more precision, over longer distances. Naarden and Utrecht, the most important cities in the NDW, were both located on the eastern edge of the waterline and were only protected by narrow, incomplete inundations. This made them vulnerable to an attack with this new artillery. Therefore, at both cities complexes of detached fortifications were built. It deepened their defence, making them less vulnerable to an attack with rifled artillery. The space enclosed by the detached forts could be used as an entrenched camp where the field army could retreat.[5] From there, the army could regroup for another attack or start an orderly retreat behind the waterline. The construction of these two fortification complexes is the third building stage of the waterline (1865-1880). It overlaps with the fourth building stage, discussed below.

Around Naarden three detached forts were built between 1868 and 1870. Two of them were made entirely out of earth. Between those two lay a third fort. It was bigger and housed several bombproof, brick buildings. Because they were built on the high ground surrounding Naarden the forts had dry ditches. This makes them unique in the NDW. The ditch of the central fort was defended by a freestanding wall with embrasures and caponnières, also a unicum in the Netherlands. The fort still exists today and is known as Fort IV. Between 1877 and 1879 two extra forts were added to the existing three. They too were made entirely out of earth. Of these four earthen forts practically nothing remains.

Around Utrecht, six new forts were built between 1868 and 1880. Together they formed the second fortification ring of Utrecht. The first fortification ring dated from 1815-1828 and consisted of six forts as well. These older forts were located much closer to the city.

The central position of this new ring was taken by the forts Rijnauwen and Vechten (both finished around 1870). The two forts took over the task of the four demi-lunes from 1828, defending the Houtense Vlakte. Besides that, their guns controlled the railroads entering Utrecht from the east. In 1880, as an extra defence to the south, Fort 't Hemeltje was added to the complex.

Figure 36. Aerial view of fort Vechten in the 1930's. On the left the railroad track is visible. This fort has a bastioned trace with polygonal characteristics.

Fort Rijnauwen is a polygonal fort, heavily inspired by the Brialmont fortresses around Antwerp. As a matter of fact, Brialmont was involved in the design process of this fort. It is the largest and most richly decorated fort of the NDW. The design of Fort Vechten is a cross between a traditional bastioned fort and a modern polygonal one. Just like Fort Rijnauwen this fort is equipped with a large reduit and casemates with guns defending the ditch. Fort 't Hemeltje, not equipped with a reduit, is a simpler version of Fort Vechten. These three forts show a next step in the development of fortification: a separation between the long-distance defence, with guns located in the open air on top of the fortress walls, and the short distance defence of the direct surroundings of the fort, with guns housed in casemates. The other three forts of this new fortification ring around Utrecht were more traditional earthen forts with bombproof buildings.[6] All six forts still exist today.

The inundation system improved

In the meantime, the political situation in Europe was changing. Prussia's power was rising. The wars against Denmark and Austria, in the 1860's, showed that in the quest for power, the Prussian government wasn't reluctant to wage war. Since both Luxembourg and Limburg were part of the German Bond and fell under the sovereignty of the Dutch king, a Prussian attack on the Netherlands was not unthinkable. With the Luxembourg crisis in 1867, it almost became a reality. From that moment on it wasn't just the French that might attack the Netherlands, it was the Prussians as well and they were much closer to the border. To make things worse, they had shown their ability to organize a rapid, efficient mobilisation of the army. It became possible that the Netherlands were invaded with such speed that the country would be overrun before the NDW was completely inundated. With that in mind, it is not surprising that improvement of the inundation speed became an issue in the 1860's.

For its water, the NDW depended on the existing network of regular, day-to-day, waterways and sluices. Of course, adjustments and additions were made for military

Figure 37. Aerial view of fort 't Hemeltje in the 1930's. This fort shows a similar mix between systems as Fort Vechten, although the polygonal trace is more dominant here. The retreated flanks of the two bastions in the front of the fort, house casemates that are accessible through a postern from the terre-plein.

Figure 38. Fort Rijnauwen in 2018.

Figure 40. The fort-keepers house at Fort 't Hemeltje today with the bombproof barracks in the background.

purposes, but there was no independent, military inundation entity. The basis of the inundation network was formed by the primary waters: the large rivers crossing the country and the Zuiderzee (the current IJssel lake). The secondary waterways were fed by those primary waters.[7] From there the water was led to the inundation basins, via sluices and canals. When inundation became necessary, water in the rivers and canals was raised by dams and locks, to create a larger water supply. This was done in three stages, following the development of the military threat. It started with raising the water until all canals in the inundation basins were filled and the land was wet and marshy. After this, in two stages, the water was raised until the maximum inundation level was reached. This whole process took about twenty-six days. To speed things up in case of emergency sections of dikes were designated to be breached.

In the face of the modern, fast-moving armies, inundations needed to go faster. Over the years, new sluices along the rivers were added, new canals dug, and existing waterways deepened and straightened to get a more effective waterflow. This already started in the 1840's. But that wasn't enough. To get more water, quicker to the waterline, sluices needed to be built more upstream of the big rivers to profit from the higher water level there. So, in 1866 and 1875 new sluices were built at Tiel and Wijk bij Duurstede. From there, through new canals and existing waterways, more water could be transported to the inundation basins of the NDW. These measures reduced the inundation time to four to twelve days, depending on the water level in the rivers.

The risks of reliance on water, the construction of Fort Pannerden

It is interesting to note that the NDW's heavy dependence on water had been a point of critique from the start. In a report from the Napoleonic period, written in 1811, E. Paris, the French Colonel Directeur des Fortifications,

Figure 39. Fort Rijnauwen in 2018, the entrance of the Reduit.

Figure 41. The retreated flank of one of the bastions at Fort 't Hemeltje, housing the casemates

Figure 42. The interior of one of the casemates.

discusses the waterline and finishes with some reservations about the defence system. In his opinion the waterline is weak because if one fort falls, the whole system collapses. Because of that the whole waterline must constantly be manned and surveyed. This will cost many men and they will be dispersed over a large area. The water supply in summer can be uncertain due to droughts. During winter the defence line can become untenable due to frost. Then he asks whether, it wouldn't be a better alternative to turn Naarden, Utrecht, Vreeswijk and Gorinchem into strong fortified cities, from where the whole region could be controlled without the need for inundations. This would take just as many soldiers but would give greater assurance in the defence. Inundations could be used as a supplemental defence, and not function as the backbone of it.[8] In the 1860's Brialmont raised

Figure 43. Fort Pannerden in 2015. On the foreground the dry ditch, defended by a double caponniere. Above the entrance, one of the armoured casemates is visible.

similar questions when he was involved in the design of Fort Rijnauwen.[9] He stated that it was too risky to lean so heavily on such an insecure defence medium.

Despite the creation of new sluices and canals, there still was one more threat that needed to be addressed. This was the possibility of an invading army cutting of the water supply to the NDW by blocking the Rhine at the point where it enters the Netherlands, near the small village of Pannerden in the east of the country. Here the Rhine, coming from Germany, separates into the smaller rivers Waal and Lower Rhine. If the Lower Rhine were to be blocked at this point, by sinking a ship there for example, the water supply to the NDW would be almost completely cut off. To prevent this, Fort Pannerden was built at this separation point. A large polygonal fort with caponnières on each of its corners. The main battery of the fort, overlooking the separation point of the river, consisted of armoured casemates. It was designed to withstand a siege independently. Under the thick earth cover lay a large complex of bombproof buildings, turning the fort into a small, fortified city, with a bakery, apothecary, ice cellar and hospital. Besides assuring the water supply of the NDW the fort could also prevent the transport of large equipment via the river. Work on the fort started in 1869 and at the beginning of 1872 it was finished. With the concerns for the water supply in mind, it is interesting to note that no fortifications were built to protect the new sluices at Tiel and Wijk bij Duurstede. They were placed far to the east, outside the reach of the defences of the NDW. This makes the critique about the dependence on water, mentioned above, even more important.

The switch to a concentrated defence, the fourth building stage

As already described, rifled artillery could fire with more precision, over greater distances. Apart from that, the

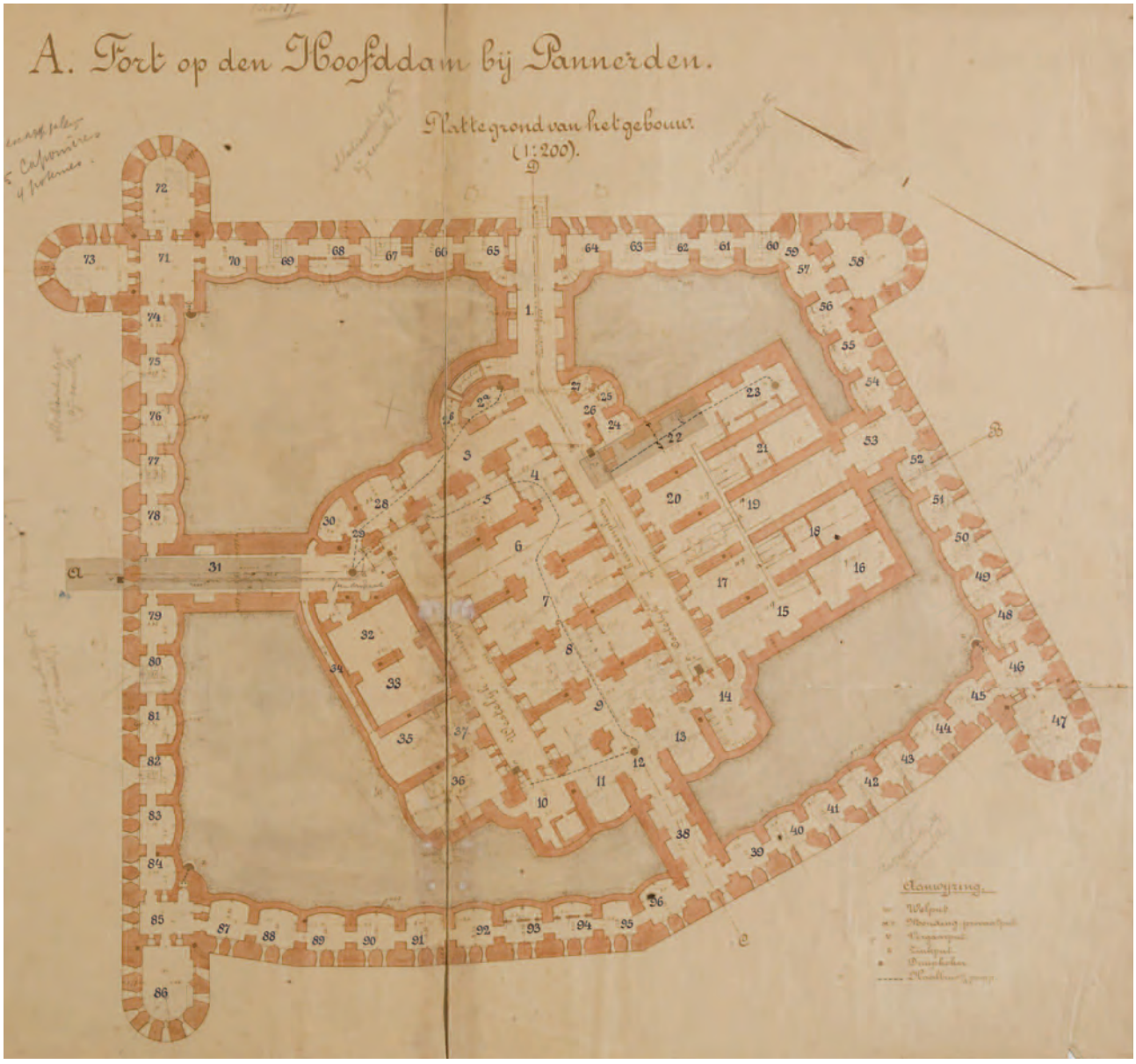


Figure 44. Floorplan of the ground floor of Fort Pannerden, showing the huge underground complex this fort is.

impact of the shot was more devastating than before. Only the bombproof buildings and casemates of the new forts at Naarden, Utrecht and Pannerden were strong enough to withstand a bombardment with this new artillery. In these forts, the buildings were covered with thick layers of earth to smother the impact of the shells. All other forts were completely outdated. Freestanding brick structures could easily be devastated by these new guns. This included the large circular towers and other buildings constructed between 1840 and 1865. All of them needed to be covered with earth. This problem wasn't addressed until after the Franco-Prussian War (1870-1871). Although the Netherlands remained neutral during this war, the conflict had a large impact on the Dutch national defence for several reasons.

Firstly, during the war rifled artillery was used on a large scale. Its destructive power made it abundantly clear that all fortresses of the NDW, constructed before 1865, needed to be modernized.

Secondly, at the start of the war the Dutch army had been mobilized. The mobilisation showed a great lack of barracks and bombproof shelters in all fortifications. Even in the newest forts. All this led to an intensive modernisation campaign of all fortifications of the NDW. It is the fourth building stage of the waterline (1872-1880).

During this campaign the existing, freestanding, brick

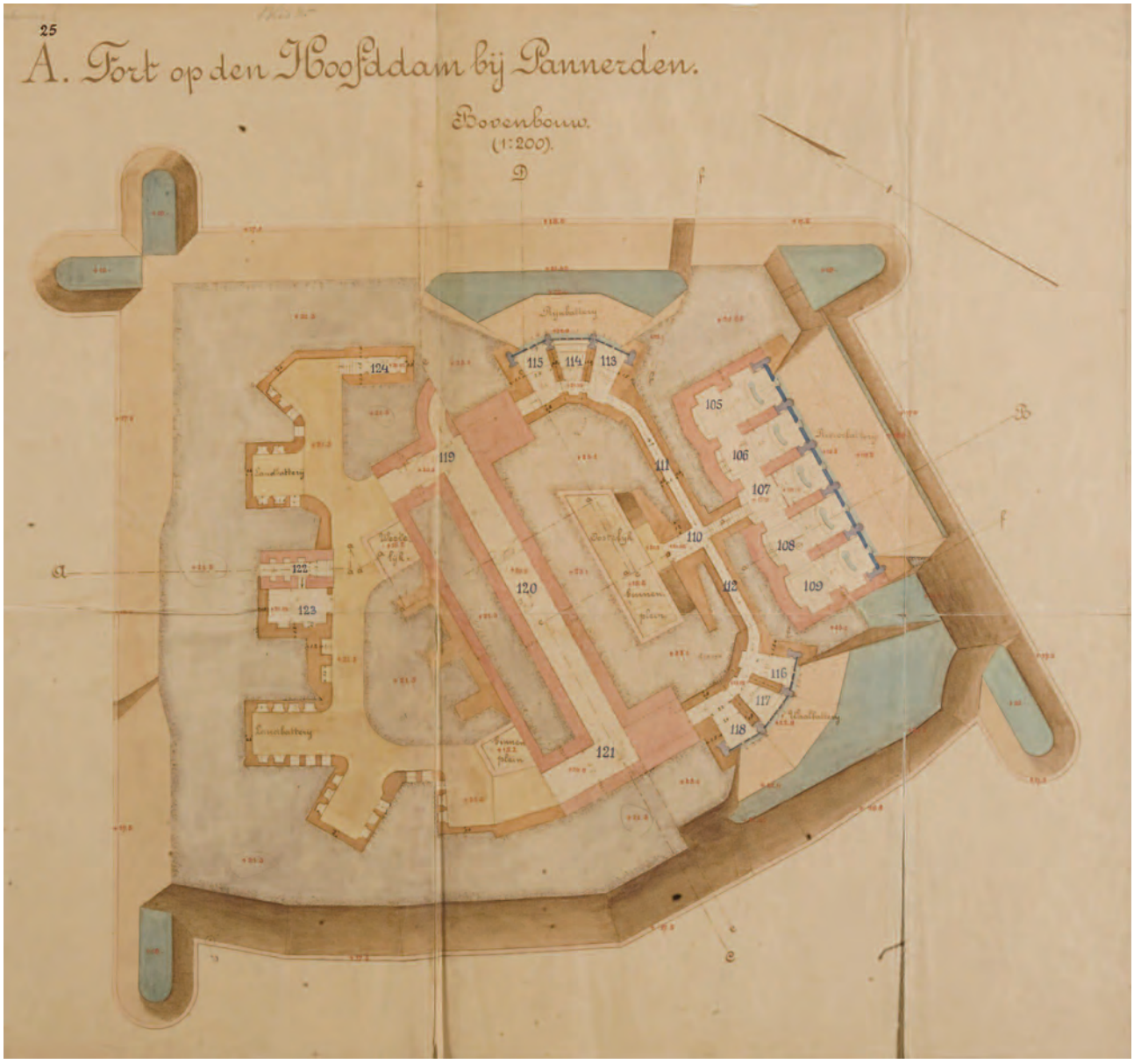


Figure 45. Floorplan of the casemates of Fort Panneren.

buildings were covered with thick layers of earth. New bombproof barracks, shelters and storage facilities were added to the fortifications and the earth walls of most of the forts were reinforced and raised with their parapets broadened. These modernizations took place in a different way in each fort, depending on the importance of the fort and the available space.[10] It is not possible to describe each separate modernization here however, the illustrations for this article show a few representative examples. It is interesting to note that the new, modern forts Vechten and Rijnauwen got large new barrack buildings during this building stage too.

The Franco-Prussian War led to a modernization of the Dutch national defence policy as well. The war had shown that in a war against a great military power, like France or Prussia, the only hope of survival for the Netherlands was the concentrated defence system. This made an end to the discussion started in 1840, mentioned above. With the Fortress Law of 1874 this concentrated defence system was made official. Defence lines and fortifications were to be concentrated around Holland and other fortifications were to be demolished. The territory outside Holland would only be defended by the field army. Amsterdam would be defended by a newly constructed defence line and get the function of National Redoubt. Here the government, the army and a part of the population could

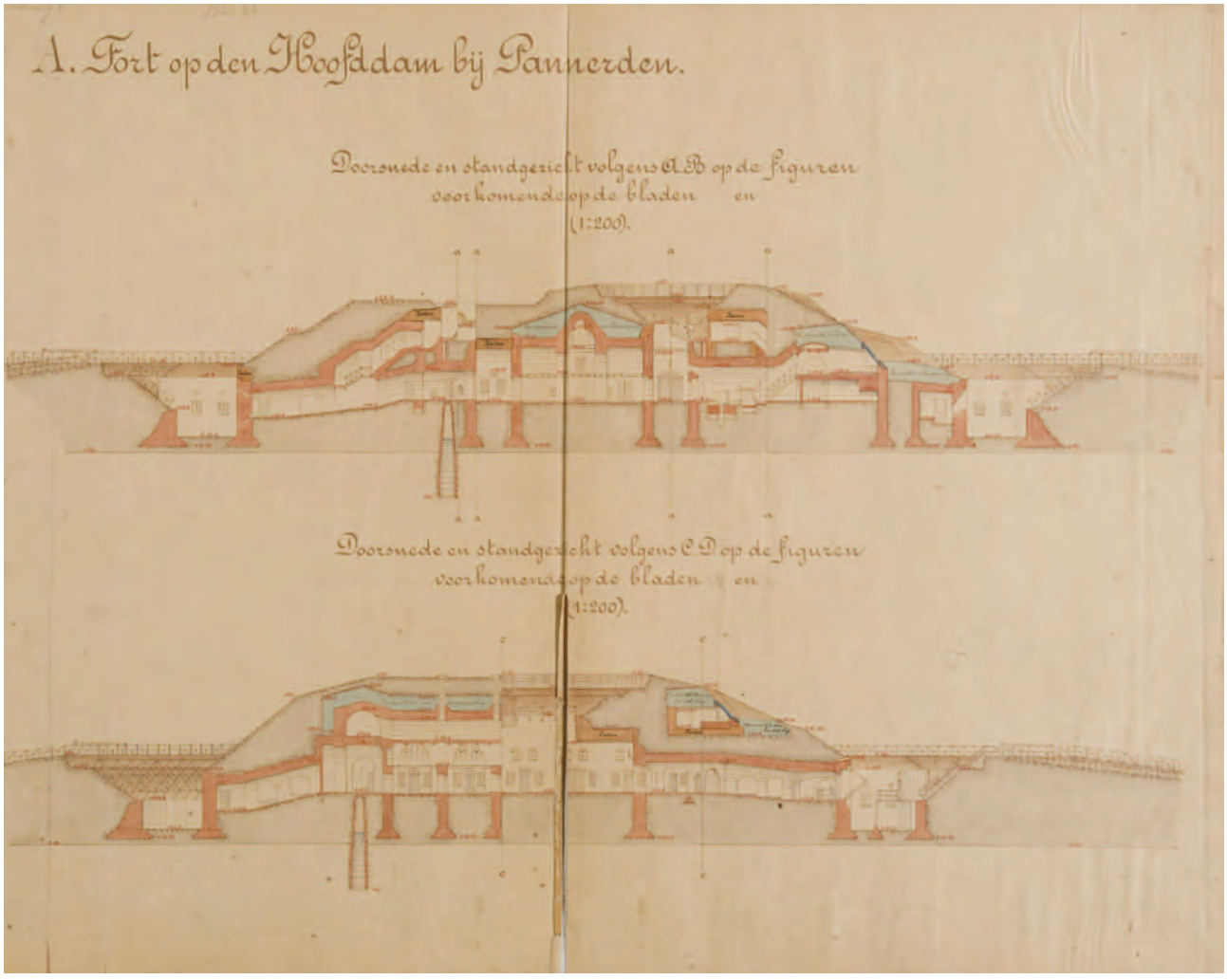


Figure 46. Cross-sections of Fort Pannerden showing the concrete reinforcements of the casemates and gun positions in light grey. The rest of the fort is covered in a less durable kind of concrete, shown in orange.

retreat as a last resort during an invasion of the country.

High explosive shells, the fifth building stage

During all these developments, weaponry and ammunition kept on evolving. By the time the fourth building stage was finished, most of the buildings had become outdated due to the introduction of the high explosive shell. Brick buildings covered with thick layers of earth were no match for the power of these new explosives. Only concrete was. In theory this meant that another modernization campaign of the NDW had to take place. The Dutch government chose not to do this, but to focus on the construction of the defence line around Amsterdam instead, limiting the adjustments of the fortresses of the NDW to local, small-scale reinforcements. This period can be described as the fifth building stage of the waterline (1885-1914). It is characterized by a further separation of long- and short-distance warfare. Guns for the long-distance defence were placed in the field, between and behind the fortifications. More and more, fortifications were used for storage, support and as a place for the soldiers to retreat and fight the short-distance battle.

The limited adjustments that were made to the fortifications of the NDW consisted of the covering of brick buildings with a layer of concrete or the addition of small concrete shelters. These adjustments are mostly discrete and difficult to decern, but there are examples of them throughout the whole of the NDW. One clearly visible example is the construction of twelve bombproof shelters along the covered way in Naarden between 1895 and 1905. The military role of the fortress had shifted from the ramparts to the covered way and the countryside.

It is interesting to note that Fort Pannerden underwent a major modernization during this period. After all, it was an

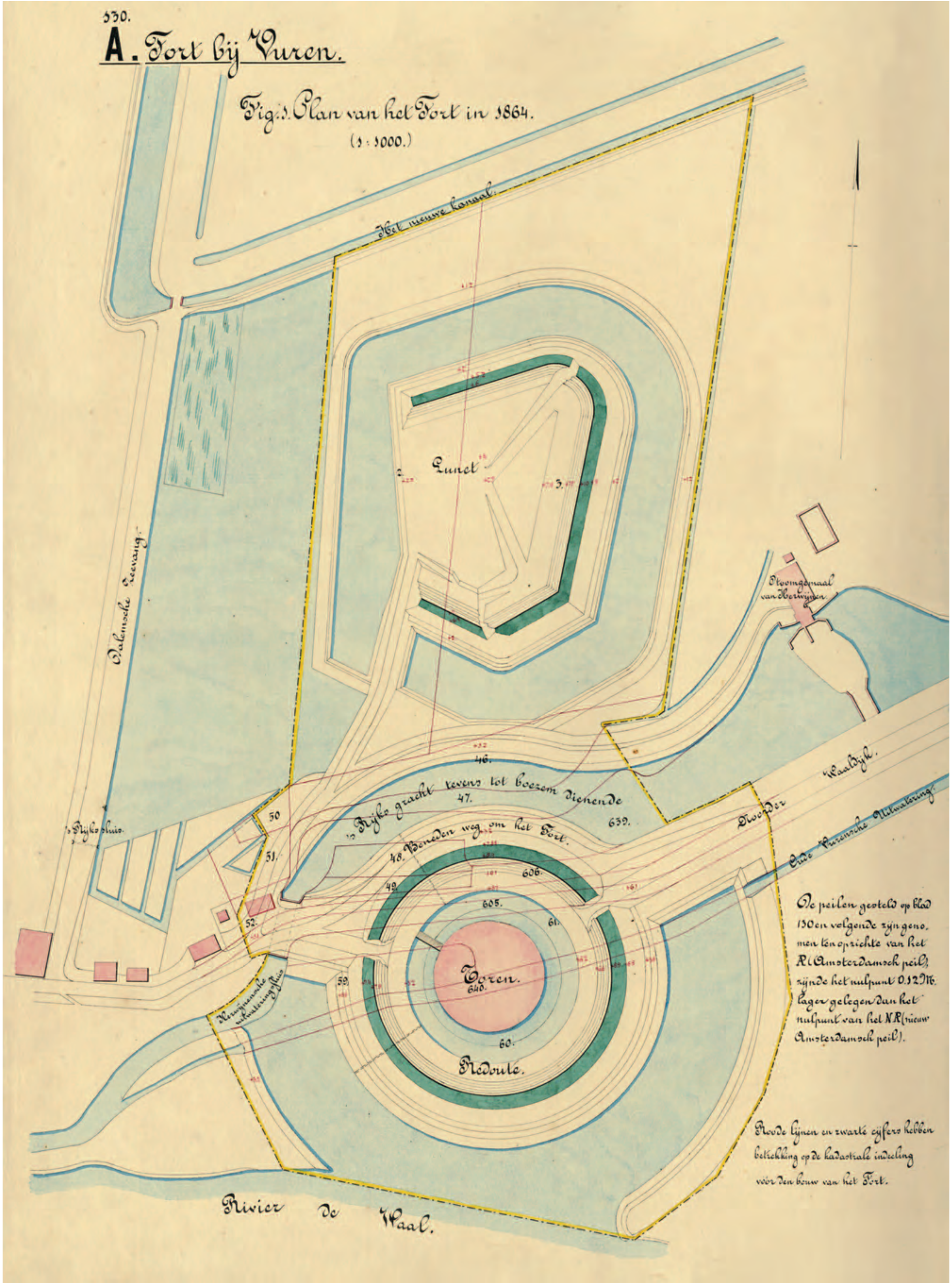
Figure 47. The concentrated defence resulting from the Fortress Law of 1874.

1. The New Dutch Waterline.
2. The Defence line of Amsterdam.
3. The Grebbe-line.
4. The Defence-system of Den Helder.
5. The Defence-system of Brielle and Hellevoetsluis.
6. The Defence-system around Willemstad.
7. The Southern Waterline.

Figure 48 (Overleaf). During the fourth building stage, the tower forts were modernized. Fort Vuren is an emblematic example of that.

Figure 48a shows the fort as it was in 1864: a tower fort defending the river dike. The tower was surrounded by an earth wall and a ditch. The north-side of the fort got an extra defence in the form of a demi-lune.

Figure 48b shows the modernized fort. The tower fort and the demi-lune are integrated in one new fort. The earthworks of the fort have been modernized by changing the parapet and the addition of traverses. New bombproof buildings are added. The tower fort is protected from direct fire by the addition of a semi-circular barrack building, covered with a thick layer of earth. This building is only added on the side where an attack was expected, the east. The tower is partly covered with earth as well.


130.
A. Fort bij Vuren.
Fig. 1. Plan van het Fort in 1864.
(1 : 1000.)
Het nieuwe kanaal.
Lunet
Stoomgemaal van Beuningen
Rijks gracht tevens tot boezem dienende
Beneden weg om het Fort.
Waaldijk.
Oude Vuurensche Uitwatering
Toren.
Redoute.
Rivier de Waal.
De peilen gesteld op blad 130 en volgende zijn genomen ten opzichte van het A.P. (Amsterdamsch peil), zijnde het nulpunt 0.12 M. lager gelegen dan het nulpunt van het N.A.P. (nieuw Amsterdamsch peil).
Roode lijnen en zwarte cijfers hebben betrekking op de kadastrale indeeling vóór den bouw van het Fort.

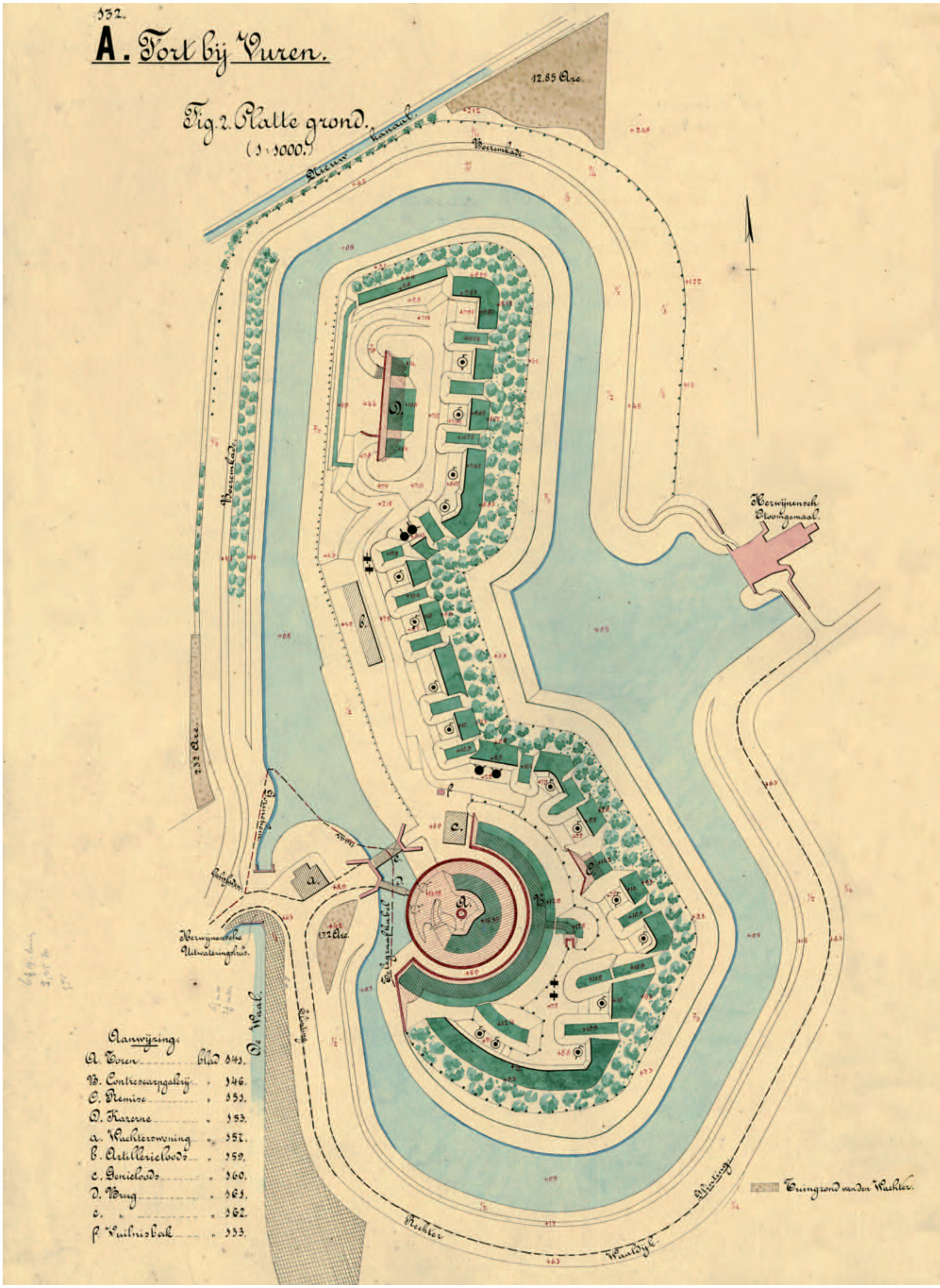

132.
A. Fort bij Vuren.
Fig. 2. Platte grond.
(1 : 1000.)
12.85 Are.
Nieuw kanaal.
Boezemkade.
Herwijnensch Stoomgemaal.
2.32 Are.
Herwijnensche Uitwateringssluis.
1.72 Are.
De Waal.
Aanwijzing.
A. Toren blad 141.
B. Contrescarpgalerij " 146.
C. Remise " 151.
D. Kazerne " 153.
a. Wachterswoning " 157.
b. Artillerieloods " 159.
c. Genieloods " 160.
d. Brug " 161.
e. " " 162.
f. Vuilnisbak " 133.
Tuingrond van den Wachter.
Rechter Waalbijl.

Figure 49. Fort Vuren in 2014. On the left the tower fort with its earthen parapet. On the right the start of the semi-circular barrack building is visible.

Figure 50. Aerial view of Fort Vuren from the 1930's. The tower with the added barrack building is clearly visible.

Figure 51. The tower of Fort Honswijk underwent a similar change. On the right the tower. Its top storey was removed during the modernization. On the left the semi-circular barrack building that was added to protect the tower from direct fire coming from the east.

Figure 52. During the modernisation this decorative, bombproof gatehouse was added to the fort as well.

Figure 53. Aerial view of Fort Honswijk around 1950. The tower with the semi-circular barrack building is clearly visible on the right, just like the other bombproof buildings added during that same modernization campaign.

Figure 54. Not all towers were modernized by the addition of a barrack building. In Fort Asperen, there wasn't enough room, so the earth covering was put directly against the existing tower. The new bombproof building under this earth covering was used for storage since it wasn't suited as a barrack.

Figure 55. The tower of fort Altena which was only one storey high was encapsuled in the earthworks of the two large barrack buildings added to the left and right of the tower. This photo shows one of the two barracks.

isolated fort, with an important strategic role. The fort was excavated. After this, the brick construction was covered with a thick layer of unreinforced concrete and covered with earth again. The existing casemates were replaced with new armoured constructions and new casemates were added.

Discussion, different thoughts on the waterline

The modernization process after the Franco-Prussian War up until the end of the nineteenth century was accompanied by many discussions about the NDW and its role within the Dutch national defence. Part of the discussion focussed on the improvement of the strength of the individual fortifications. According to some, looking at the increased speed of mobilization, it became more and more urgent to have a defence line capable of resisting attack, without the use of water. Just like Paris and Brialmont had already mentioned in the past. After all, it could very well be that an invading army reached the waterline before it was inundated. In that case the whole defence depended on the fortifications and their current strength wasn't up to that.[11]

The plans revealed in the book by Kainos went even further.[12] The writer wanted to create an extra line of defence in front of the inundation area. From there an active defence could take place. Such a defence was impossible from the current fortifications because they were located behind the inundations. The narrow accesses they were supposed to defend would hinder an offensive sortie. The new defence line would remedy this. Besides that, the extra layer in the defence could create time to get the whole system inundated. In that case the actual waterline would be the final retreat when the active defence became impossible. The plans were never realized.

Others were more radical and only saw a role for the waterline as a means to slow an enemy down, while army and government retreated to the Defence Line of Amsterdam, from where the actual defence would take place. In that situation the NDW got a role as a temporary defence line. Others just wanted to get rid of the waterline altogether.[13]

On the other side of the spectrum were the supporters of the waterline. In their opinion the particular strength of the Dutch national defence lay behind the waterline and not in front of it. One of the most difficult terrains to fight

Figure 56. Example of two bombproof buildings in Naarden (1875). From 1875 until 1885 within the perimeter of the 17th century fortifications a completely new complex of modern bombproof buildings was constructed. This shows a 17th century ravelin with two 19th century buildings added to it.

in, was the polder: an open landscape, with much water and narrow roads from where defenders could open fire from all directions.[14] If an enemy would ever succeed in passing the NDW he would get lost in the open landscape behind it, where there were even more possibilities of inundating land.[15] Despite all these discussions nothing changed. The waterline kept its role as a vital part of the national defence.

Small shelters and an explosive sluice, the sixth building stage

The First World War showed that even the most modern fortresses, like those around Amsterdam, with thick, unreinforced concrete constructions and steel cupolas, were not capable of withstanding a bombardment with the newest explosives. Small casemates and shelters, constructed in reinforced concrete, became the norm. They were connected by networks of trenches and barbed wire. Fortresses and fortified cities got a secondary role and many of them lost their military purpose. Between the two World Wars, these new concrete buildings appeared everywhere in the NDW. Inside the forts, around them and in the countryside between them. Their shape changed over time and varied according to their function. Especially around Utrecht the network of these buildings was dense, and it is still very present in the landscape. The construction of these small concrete buildings is the sixth, and last, building stage of the waterline (1914-1940).

Several of these small, concrete buildings are shown in the illustrations of this article. But there is more. Some of the largest and most curious constructions of the NDW date from this last building stage. They are related to the new roads and canals constructed in the 1930's.

To begin with the roads: During this decade the first network of highways was constructed in the Netherlands. This included the highway from Utrecht to 's Hertogenbosch. The road crossed the waterline, creating two problems. The first was that the new road formed an access. This was solved by building several concrete casemates to control the road with artillery fire. The second problem was that the road crossed a dike of one of the inundation basins. It made a breach in it as it were. In case of an inundation, water could flow away through this breach. To prevent this from happening, the breach in the dike was bridged by a viaduct. This viaduct held two large sluice doors that could be closed if needed, thus temporarily repairing the water barrier, and saving the inundation. The dike also formed a primary water barrier,

Figure 57. One of the concrete shelters build on the covered way in Naarden.

Figure 58. Fort 't Hemeltje. In the late nineteenth century, a concrete addition was made to this brick building.

Figure 59. Casemate type G from the 1930's: consisting of a concrete construction with a small cast-steel dome added to it, housing a machine gun. Most of these steel domes were removed during WWII. In Fort Vechten they still exist. It is a rarity.

Figure 60. This type of concrete group-shelter, type P, can be found all through the waterline. They date from the 1930's.

Figure 61. This casemate in Fort Kijkuit is unique. To the concrete construction (1935) this armoured front was added. It used to be part of the armoured ship Hr. Ms. Tromp *and was re-used in this fort.*

Figure 62. Between Fort Vechten and Fort Rijnauwen a series of these concrete shelters can be found. They date from 1918.

protecting the land behind it from flooding in case of natural high waters. So, the sluice-viaduct wasn't only a military construction but a civilian one as well. That's why it kept functioning well after the NDW had lost its military purpose. In 2006 it was replaced by a more modern sluice-viaduct that is still in use today.

Then the canals: In 1934 the work on the canal connecting Amsterdam to the Rhine was started. This canal crossed the waterline just south of Utrecht, creating similar problems. Water from the inundation basins, could flow away through the canal. Besides that, it formed an access. This led to the creation of the Explosive Sluice. It is the last construction to be added to the NDW. Simply put, this sluice consists of a series of large concrete reservoirs. Together, they form a 120 metres long viaduct over the canal. The reservoirs are filled with sand and rubble. In case of an attack, the bottom of the reservoirs could be exploded, causing the rubble to fall into the canal, between sluice doors that had been closed shortly before. The canal would be blocked, the access closed and the inundations safe. The Explosive Sluice wasn't ready when World War II broke out. The construction was finished but never used. The sluice still exists today, mainly thanks to the fact that destroying it turned out to be too expensive. It is the largest and strangest construction of the NDW.

The end of the waterline

Soon after these two constructions were conceived the Second World War broke out. In May 1940, the Germans simply flew over the waterline to land troops behind it and bombard Rotterdam. It showed that the waterline had become an old-fashioned means of defence. Theoretically, the water plains of the NDW could have caused a delay for the invading forces on the ground, but faced with the threat of more destructive bombardments, the Dutch government capitulated before the German troops even reached the waterline. Besides that, there were only local inundations. At the end of the war, the Germans decided to use the waterline as a barrier to stop, or slow down, the Allied forces. Large parts of the NDW were inundated. To no avail, the Germans capitulated before the Allied forces reached the water barrier.

It is interesting to note that just before the outbreak of WWII, in March 1940, the Dutch defence strategy was changed. The main defence line was replaced from the NDW to the Grebbe-line, located more to the east. One of the reasons behind it, was that the land there gave more possibilities for cover, the movement of troops and offensive actions. These thoughts fit in the discussions mentioned above and the ideas of Kainos.

After the war, new discussions about the military strength of the NDW were no longer needed. The defence

Figure 63. The Explosive Sluice near Nieuwegein today. One of the most special constructions in the waterline.

line officially lost its military purpose in 1951. From that moment on, slowly but steadily, the NDW became better known to the public as part of the Dutch history and as military heritage. The forts received the status of national or local monument. Many of them opened their doors to the public and got a new life as museum, bed and breakfast, activity centre, brewery etc. Eventually the whole defence line received the World Heritage Status in July 2021.

Biographical Note

Jeroen van der Werf (b. 1973) is an engineer and building historian. He works for the Monuments Foundation and is responsible for the maintenance and restoration works on the fortifications of Naarden. Besides that, he conducts historic research on fortifications in general and those of Naarden in particular. He is secretary general of the International Fortress Council.

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- Imagebank Rijksmuseum: 1 (fragment of a larger map), 2, 4 and 10 (details), 30 and 33 (details with numbers added by author)
- Imagebank Programmabureau Nieuwe Hollandse Waterlinie: 3, 5, 6, 15, 26
- Imagebank Nederlands Instituut Militaire Historie: 7, 18, 34, 35, 36, 49 (fragment), 52
- Federica Marulo: 11
- Imagebank Nationaal Archief: 13 and 14, 17, 19, 23 (details of that map)
- Stichting Menno van Coehoorn: 22, 47a, 47b
- Imagebank Noord-Hollands Archief: 31
- Imagebank Gelders Archief: 43, 44, 45
- Stichting Monumentenbezit: 46, 55
- All other images by the author.

Notes

1. In most of today's literature an inundation depth of 30 to 50cm is mentioned. In nineteenth century literature this is slightly different. In *Militaire Aardrijkskunde* on page 235 and 236, a depth of 15 to 50cm. is mentioned. At first glance a depth of 15cm seems very shallow. With the overall quality of the underground of the inundation basins in mind (clay or peatland) this depth can be enough. With just a little water the ground will become soggy and impassable. A sandy underground would in principle need a larger inundation depth than 50cm, but that would mean an enemy could sail across the inundation. So, this type of underground forms a risk. Fortunately, sand is rare within the inundation area of the waterline.
2. On the same two pages in *Militaire Aardrijkskunde* (235 and 236), the interesting nuance is made that the ground level within the inundation basins fluctuates, so there will always be parts that theoretically could be crossed (note 1 on page 235). In other words: it is impossible to make the perfect inundation.
3. Another enemy of the waterline was of course frost. Once frozen the waterline was useless. There were special protocols for dealing with these circumstances and preventing the water barrier from freezing shut.
4. These are the towers at: Muiden (West Batterij), Fort Uitermeer, Weesp (Ossenmarkt), Fort Nieuwersluis, Fort de Klop, Fort Honswijk, Fort Everdingen, Fort Asperen, Fort Vuren and Fort Altena.
5. In the case of Naarden this function was somewhat theoretical. Documents of that time (the Memorandums of Defence) show a certain skepticism towards this function.
6. Of these three forts, Fort Voordorp, built in 1869, was turned into a fort with a polygonal front in 1879. This made it look like fort 't Hemeltje or Vechten. It had a role in the defence of the railroad entering Utrecht on the north-east side.
7. Salt water caused damage to farmland and crops and was avoided as much as possible for inundations. Theoretically it was possible to inundate the whole waterline with sweet water, but the use of salt water could not be excluded. There was a chance that water from the Zuiderzee in Muiden would be led into the northern inundation basins.
8. *Napoleontische Studien*, page 597 to 600.
9. *Torens Wallen en Koepels*, page 132
10. Some forts weren't modernized because they lay in the second line of defence: Fort de Klop, Fort Vossegat, Fort Jutphaas and the tower fort at Muiden (Westbatterij).
11. The plans for Naarden, discussed in Jeroen van der Werf's article in Fort 48 must be seen in the light of this discussion.
12. *De Nieuwe Hollandse Waterlinie en hare verbetering aan de Eischen des Tijds* (1874). The whole book revolves around this idea.
13. *Het vaderland verdedigd* page 81. These ideas date from 1880. One of the arguments for this was that the waterline would absorb too many soldiers to leave an effective filed army for the first defence.
14. Ibid. page 79 and 80.
15. It is interesting to compare this situation to the Russian-English invasion of Holland in 1799. Here the invading army struggled for several weeks to get through the polders toward Amsterdam. It didn't work and it proves the difficulty of fighting in this type of landscape.