Beyond the dyke

Flood safety options

2024

Netherlands Court of Audit

Content

1. Executive summary

Imagine

You live in Gouda and it's raining. Hard. The heavens have opened. Non-stop for two days. The water washes over the dyke. By day 1, the streets are inundated and the river is flowing through your kitchen. The lights go out that evening and water doesn't come out of the tap. It's cold, the central heating has stopped working. The wifi is dead and the battery in your mobile is slowly running out. You start hauling furniture upstairs but the waters keep rising. Without an emergency kit, clean drinking water, a torch and a rescue boat, what can you do? Your parents also live in a flooded part of town but you can't contact them. How could this happen in the Netherlands? Happily, the scenario isn't true. But it is becoming more likely.

The Netherlands: a country of dykes

Our dykes are world famous: strong dykes meander across the land to protect the country and keep millions of people safe and dry. Building, maintaining and reinforcing them is a vital government task. The government is currently working on a major dyke reinforcement programme with completion planned for 2050 at a cost of more than €13 billion (according to the latest, 2023, estimate). It has invested huge resources in learning more about the risk of dykes overflowing or bursting and developing new solutions to strengthen them. The government is keeping a keen eye on the cost: every euro invested in the dykes has to be cost effective.

Flood safety increasingly important

The main strategy to protect the Netherlands from flooding is dyke reinforcement. The Minister of Infrastructure and Water Management (I&W) nevertheless wants to

do more to protect the country. Even the strongest dykes cannot always prevent flooding, as was demonstrated in the province of Limburg in 2021. Climate change is increasing the risk of flooding. Rising sea levels, extreme rainfall and high river discharges are subjecting the dykes to ever more pressure. At the same time, more people are living behind the dykes and more businesses are setting up their shadow. The minister therefore wants to take additional measures to protect the people behind the dykes. His ambition is to maintain the Netherlands as the best protected delta in the world.

Multilevel safety

To realise this ambition, the minister has been working on a new flood protection strategy since 2009. Known as multilevel safety, it is made up of 3 protection levels. Level 1 comprises measures to prevent dykes bursting or overflowing. They include dyke reinforcement and river widening. Level 2 comprises spatial planning interventions to mitigate the impact of a dyke burst or overflow. They include emergency inundation areas, houses on stilts and planning measures to divert floodwater away from built-up areas. Level 3 is crisis management, in the form of evacuation plans and public information campaigns on what to do in case of flooding.

Multilevel safety making slow progress

Several studies have concluded that flood protection behind the dyke (levels 2 and 3) is making slow progress in the Netherlands. We analysed why this is and how the Minister of I&W can strengthen his grip. We looked at the minister's policy on dyke reinforcement. This policy allows dyke managers to take other measures than dyke reinforcement, such as river widening (a level 1 measure) and damage mitigation behind the dyke (levels 2 and 3). Dykes are managed by Rijkswaterstaat (the Directorate-General for Public Works and Water Management) and the regional water authorities, who carry out dyke reinforcement projects. We investigated whether Rijkswaterstaat and the water authorities considered alternative options in their dyke reinforcement plans.

We found that dyke managers often considered measures in the river and behind the dyke but soon abandoned them. In 65%% of the projects we looked at, dyke managers opted for only dyke reinforcement. In 30% of the projects, dyke reinforcement was accompanied by secondary 'river measures', such as raising river banks to slow down waves or reducing drainage from the water system behind the dyke in order to control the water level in the river. Only 5% of the projects we audited included damage mitigation behind the dyke. The measures included emergency inundation areas and the construction of an inner dyke.

Why are measures behind the dyke making slow progress?

We also investigated why dyke managers did not include measures beyond the dyke. Dyke managers are sensitive to public opinion. Public opposition can seriously delay a project and thus increase the risk of flooding. Water authorities and Rijkswaterstaat accordingly seek solutions that enjoy popular support. There is often scant support for measures behind the dyke, where residents already feel safe and oppose far-reaching interventions, especially ones that do not reinforce the dyke, radically alter the landscape or are costly to residents themselves (for instance, to adapt their homes).

Besides public acceptance, costs are a decisive factor. The minister keeps a very keen eye on costs. We found that it was very hard for dyke managers to estimate the cost of damage mitigation and crisis management accurately. Reinforcing an existing dyke is often cheaper than taking innovative measures in the river or behind the dyke. This will in any event be the case until 2050, the target year for the minister's policy.

So dykes are being reinforced. Public support also helps determine how they are reinforced. People do not want higher dykes to block their view of the river and they do not want wider dykes in their back gardens. Dyke managers are therefore inclined to raise dykes slightly less than they should, but the risk of overflowing is then higher and the need for damage mitigation behind the dyke becomes more pressing. Moreover, dykes are often reinforced on the river side whereas rivers will need more space to receive water as climate change progresses.

Lastly, we also found that multilevel measures could be taken behind the dyke only if dyke managers worked with provinces, municipalities and other parties such as the State Forest Service. This is difficult and time consuming.

Our conclusions: implementation and oversight of multilevel safety needed to protect the delta

The minister has placed multilevel safety at the heart of his flood protection policy but has not developed policies and guidelines to implement it. He has not set standards for damage mitigation or learnt about the costs and benefits of multilevel alternatives to dyke reinforcement. Nor has he ensured fruitful coordination between the various parties responsible for spatial planning and crisis management. Instead, the minister is focusing on dyke reinforcement with little practical thought for multilevel safety. His policy, moreover, takes the very narrow perspective of reinforcing dykes as inexpensively as possible until 2050.

The minister must make serious work of multilevel safety by looking further ahead than 2050. And he must take a wider view, beyond the dyke towards ‘floodscapes’ in which flood safety is the outcome of measures before, on and behind the dyke. Other countries are already doing this, so it is possible. The measures can include providing home emergency kits for people who live in Gouda before it starts raining, placing domestic fuse boxes higher so that the lights stay on and building electricity substations on raised platforms, so that you can charge your mobile and contact your parents.

Flood safety embraces not only dry feet but also a functional society. Also after 2050.

2. Introduction

2.1 Flood risk increasing

Located in the delta of some of Europe's great rivers, the Netherlands has been 'fighting water' throughout its history. Early inhabitants of the low country built artificial mounds known as terps to escape from floods. The first dykes were built in around the year 1000 and the first water authority to keep the polders dry was set up in the 13th century. And the Netherlands has been draining the polders ever since. Following the disastrous North Sea Flood in 1953, the government launched the Delta Works Programme, a monumental system of barrages, dams and locks to protect against high water from the sea. Following the near floods of the Rhine and Meuse in 1993 and 1995 the government decided to make more room for the rivers and reinforce the dykes along them. These defensive works are still keeping our feet dry today. Dykes have been protecting the Dutch for so long, they tend to be taken for granted.

Extreme rain in Germany, Belgium and the southern Netherlands in 2021
Things went wrong in the summer of 2021. Extreme rainfall led to flooding in parts of Germany, Belgium and the southern Netherlands. In Germany and Belgium, where most of the rain fell, 220 people lost their lives, villages were destroyed and electricity, transport and many other basic services were disrupted (Flood Safety Expertise Network (ENW), 2021). The dykes along the Meuse in the southern Netherlands only just managed to hold back the water, but the tributaries burst their banks, towns and villages were inundated and homes and businesses suffered enormous damage and

losses (RVO, 2022). If the rain had fallen in the centre of the Netherland, in an area with deep polders such as Utrecht or South Holland, the losses would probably have been far higher (Deltares, 2022a and 2022b).

Preparing for more floods

The events in 2021 show how vulnerable the Netherlands is to flooding[1], and the situation is being aggravated by climate change. The country is subsiding at the same time that sea level is rising. Recent projections suggest the sea level could rise by as much as 1.20 or even 2 metres by 2100 and by more than 5 metres by 2300. The risk of extreme rainfall and high rivers is also increasing. A recent report by the Intergovernmental Panel on Climate Change (IPCC, 2023) indicates that sea levels are rising faster than expected and the risk of extreme rainfall is growing rapidly.

The flood risk is facing us from several sides and – despite the dykes – flooding can never be entirely ruled out. We have to be fully prepared for a disaster. Hurricane Katrina made this abundantly clear (see box below: Kates et al., 2006; Michel-Kerjan, 2010).

Devastating dyke failure following Hurricane Katrina (2005)

Hurricane Katrina caused enormous damage in the southern United States in 2005. The defensive works around the city of New Orleans were calculated to withstand the category 3 hurricane, but the dykes nonetheless burst. Storm damage put pumping stations out of service and 80% of the city was flooded for many days. Houses, especially in poorer neighbourhoods, were swept away. Flood waters trapped residents in their homes, rescue teams could not reach them and evacuation routes were impassable. 25,000 sought shelter in the Superdome, a huge American football stadium, but there was not enough food and water and the air conditioning system failed. It took many days before the stadium could be relieved. In total more than 1,800 people lost their lives and the damage was estimated at $13 billion.

2.2 Minister committed to extra protection

New multilevel safety strategy

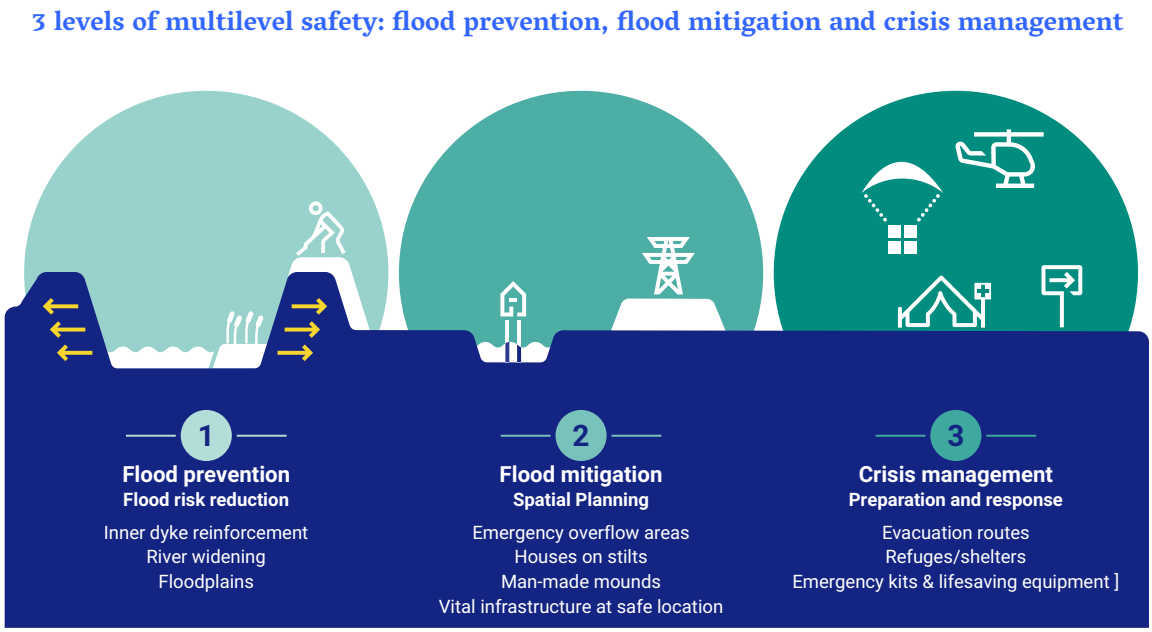
The Minister of Infrastructure and Water Management (I&W) is responsible for protecting the Netherlands from flood events. To counter the growing threat, he introduced a new policy strategy in 2009. Besides dyke reinforcement, it embraces river widening, flood mitigation and careful preparation for a flood disaster. The minister refers to this strategy as multilevel safety (National Water Plan 2009-2015). It is based on the European Flood Directive (EFD) (V&W, 2009). The EFD provides

a framework to assess and manage flood risks. Its objective is to reduce the adverse consequences for human health and life, the environment, cultural heritage and economic activity. It encourages member states to develop measures that reduce flood risk as a whole in accordance with the formula, risk = probability x impact (probability of an event multiplied by its consequences). Measures that reduce flood *risk* must be weighed up against measures that reduce flood *impact* (Foundation for Applied Water Research (STOWA), 2017 & 2019).

Multilevel safety protects against flooding at 3 levels, to use the minister's phraseology, (see figure 1). The pros and cons of the measures in each level must be carefully weighed up against each other to arrive at the best multilevel solution.

- **Level 1** (flood prevention) aims to reduce *flood risk*, for instance by building strong dykes, dams and dunes. Prevention also requires rivers to be widened so that they have enough capacity to discharge water. This is being achieved through the Room for the River programme
- **Level 2** (spatial planning) aims to *mitigate the impact* of a flood. An area can be planned so that flood water is diverted away from homes. Emergency overflow areas can be designed behind the dyke. Houses can be built higher (e.g., on man-made mounds) and fuse boxes can be placed on the top floor.
- **Level 3** (crisis management) aims to *limit the number of people affected and the financial losses*. Access and evacuation routes can be created for emergency services, muster points can be positioned on higher land and public information can prepare citizens for a potentially devastating flood.

Figure 1 *Multilevel safety: balanced consideration of the pros and cons of all levels*



Level 1 has priority

Multilevel safety has been at the centre of the government's national flood plans and programmes since 2009 (V&W, 2009; I&M and EZ, 2015; I&W, LNV and BZK, 2022). From the outset, however, the Minister of I&W has prioritised measures in level 1: the '*government will continue vigorously to implement preventive measures to avert a flood disaster wherever possible. Prevention is and will remain at the centre of the flood safety policy. […] Despite the strong emphasis on prevention, flooding can never be entirely ruled out. The government will therefore take additional measures to limit the consequences of a possible flood*' (V&W, 2009, p. 75). Dyke reinforcement has highest priority but the Minister of I&W recognises that it must take place within the wider context of, and be compatible with, other preventive measures in level 1, such as river widening and strong coastal defences (I&W, 2022a).

Alignment with levels 2 and 3 through area-based measures

In the minister's eyes, dyke reinforcement should go hand in hand with flood mitigation measures in level 2 (spatial planning) and crisis management measures in level 3 (preparation and response). The measures must be tailored to each area separately as opportunities for multilevel safety differ from one location to another (V&W, 2009; I&M, 2020).

A dyke burst can have devastating consequences in a low-lying area, especially if it is densely populated or is a key economic centre. Most dykes around such areas are very strong, but if one nevertheless fails the resultant flood can be disastrous. Before the flood waters reach densely-populated economic centres, time must be bought for a crisis management team to evacuate people. More can also be done to limit the damage to property and infrastructure in low-lying areas, for instance by using floodproof materials and placing electricity junctions on higher land. In higher-lying areas, residents must be more self-reliant and know where there are well-stocked flood refuges.

Goal: best protected delta in the world

The Minister of I&W wants the policy to maintain the Netherlands as the '*best protected delta in the world*' (I&W, LNV and BZK, 2022, p. 58). In a letter to the House of Representatives on the role of water and soil in spatial planning, he again highlighted the importance of the multilevel strategy to keep the Netherlands safe in a changing climate (I&W, 2022b).

The minister has set 2 targets for the best protected delta in the world:

- Everyone who lives behind the primary flood defences[2] will enjoy at least a basic level of protection by 2050, with the risk of flood fatalities being no greater than 0.001% per annum. In other words, the average risk is no greater than one flood death every 100,000 years.
- More protection will be provided in areas where a single event can cause many fatalities, serious economic losses and/or the failure of basic services such as drinking water and electricity.

To achieve these goals, the minister has set statutory standards on the strength of primary flood defences (see § 4.2) and launched a dyke reinforcement programme (the High Water Protection Programme (HWPP), see § 4.3), which, according to the minister, includes multilevel safety options.

2.3 Multilevel safety making slow progress

Following the floods in the southern Netherlands in 2021, various parties underlined the importance of multilevel safety. The Advisory Task Force on Flooding and High Water (2022) was set up to learn the lessons of the floods. It recommended that the government should add another 2 levels to multilevel safety: a basic level of 'flood awareness' (level 0) and a fourth level of 'recovery'; see table 1. The Minister of I&W accepted this advice (I&W, 2022b).

Table 1 *Multilevel safety with 2 additional levels*

Level 0	Level 1	Level 2	Level 3	*Level 4*
Flood awareness	Prevention	Mitigation	Crisis management	*Recovery*

Studies have shown, however, that multilevel safety is making slow progress in the Netherlands (STOWA, 2018; Driessen et al., 2018; Molenveld & Van Buuren, 2019; Oukes et al., 2022; Delta Programme Signal Group, 2022). The Delta Programme Commissioner repeatedly called on the government in 2021 to make serious work of multilevel safety but concluded in 2022 that, '*despite previous calls that, in addition to safe flood defences (level 1 of multilevel safety), flood mitigation through spatial planning and crisis management should receive more consideration, they have gone largely unheard and levels 2 and 3 are still inadequately applied*' (Delta Programme Commissioner, 2022, p.1).

Our audit investigated why multilevel safety was making such slow progress in the Netherlands. We asked whether the Minister of I&W applied multilevel safety appropriately in his flood protection policy and how it could be applied ore widely. Before we explain our audit design and approach, we first describe the Minister of I&W's flood protection responsibilities. Those responsibilities were the starting point of our audit.

Flood protection responsibilities

This section describes the Minister of I&W's responsibilities to protect the Netherlands from flood events. In broad lines, they match his water management responsibilities (see table 2). We also consider his responsibilities for multilevel safety.

Table 2 *Water management and flood protection responsibilities*

Responsibilities	Main water system: rivers and lakes	Regional water system: smaller rivers and lakes and groundwater
Water management frameworks	Minister of I&W	Provinces
Operational water management	Water authorities Minister of I&W (implementing body: Rijkswaterstaat)	Water authorities
Flood safety frameworks	Minister of I&W	Provinces
Dyke reinforcement	Water authorities Minister of I&W (implementing body: Rijkswaterstaat)	Water authorities

Water management: Minister of I&W responsible for the main water system

Water management in the Netherlands makes a distinction between the main water system (the sea and large rivers and lakes) and the regional water system (smaller rivers and lakes and groundwater) (I&W, LNV and BZK, 2022). The Minister of I&W is responsible for the main water system. Rijkswaterstaat advises on the main water system and carries out work on it. Provinces, water authorities and municipalities are responsible for the regional water system. Provinces set the policy frameworks for water authorities to implement. Municipalities have specific statutory duties of care for regional water management (such as urban rainwater drainage).

Flood safety: Minister of I&W is responsible for primary flood defences

The Minister of I&W is responsible for flood protection on the *main water system* by means of the primary flood defences (dykes, dams and locks bordering the sea and large rivers and lakes). He must formulate policy for these defences, set standards, maintain the defences and oversee their maintenance status (Water Administrative Agreement, 2011).

Operational management of the primary flood defences is performed by the water authorities and Rijkswaterstaat. Water authorities manage most – about 90% – of the primary flood defences in the Netherlands. Rijkswaterstaat manages several large defences, dams and locks, such as the Delta Works[3] and the Afsluitdijk, and the coastal defences (the dunes). Under section 5.3 of the Water Act, the dyke managers perform necessary management and maintenance work to ensure that the primary flood defences meet applicable standards.

Provinces are responsible for flood protection from the *regional water system* (smaller rivers and lakes and ground water). They set standards for regional flood defences and the discharge capacity of the regional water system. The water authorities also manage and maintain regional defences and ensure they meet applicable standards (Water Administrative Agreement, 2011).

Minister of I&W is also responsible for large rivers and coastal management

The Minister of I&W is also responsible for managing the discharge capacity of the large rivers (into the sea and Lake Ijssel) and coastal management. Rijkswaterstaat carries out the necessary work, for instance beach nourishment by pumping sand onto the beach or the seabed directly in front of the coast in order to consolidate the shoreline. The minister also sets rules to prevent construction work in floodplains compromising the room for the river (I&W, LNV and BZK, 2022).

More diffuse responsibilities and powers for multilevel safety

The Water Advisory Committee (ACW) observed in an advisory report on multilevel safety that '*limiting flood risk by means of multilevel safety is a responsibility not of the water managers but of other public bodies (provinces, municipalities and safety regions*[4]*) and private parties (citizens and businesses)*', (ACW, 2014, p. 13). Responsibility for multilevel safety is therefore more diffuse, particularly at levels 2 and 3.

Dyke reinforcement, river widening and coastal management are level 1 multilevel safety measures to reduce flood risk. In the main water system, they are a

responsibility of the Minister of I&W and in the regional water system of the provinces, as described above.

Measures behind the dyke (levels 2 and 3) are intended to limit the number of people affected and financial losses by means of spatial planning and crisis management. Within government, spatial planning (level 2) is a responsibility of the Minister of Housing and Spatial Planning (VRO). Many tasks in this area have been delegated to local authorities. Municipalities, for instance, are responsible for land-use plans, and provinces for the designation of nature areas, which can also serve as water detention and retention basins. Crisis management (level 3) is a responsibility of the Minister of Justice and Security (J&V). Municipalities and safety regions carry out important statutory crisis management tasks. Safety regions are responsible for disaster preparation and response, and for evacuation plans and routes.

Minister of I&W coordinates and oversees multilevel safety

Although responsibilities for multilevel safety are spread across several parties, the government is responsible for *coordination* and *oversight*. The Water Administrative Agreement (2011), for instance, states that the Minister of I&W is responsible for the proper functioning of the administrative system for water management in the Netherlands, including flood protection and multilevel safety. In addition, the government referred to flood protection as a 'national interest' in the National Strategy on Spatial Planning and the Environment (2020). It is therefore tasked with protecting this interest, even though some implementing measures have been delegated to local authorities and other parties. Under the Government Accounts Act (section 4.1), finally, the Minister of I&W has the general task of periodically auditing the effectiveness and efficiency of policy (in this case multilevel safety policy).

2.4 Audit design

The purpose of this audit is to *investigate* why multilevel safety is making such slow progress in the Netherlands and to express an *opinion* on whether the Minister of I&W gives it appropriate priority in his flood safety policy in accordance with the responsibilities and tasks described above. We then make *recommendations* to the minister to increase the application of multilevel safety.

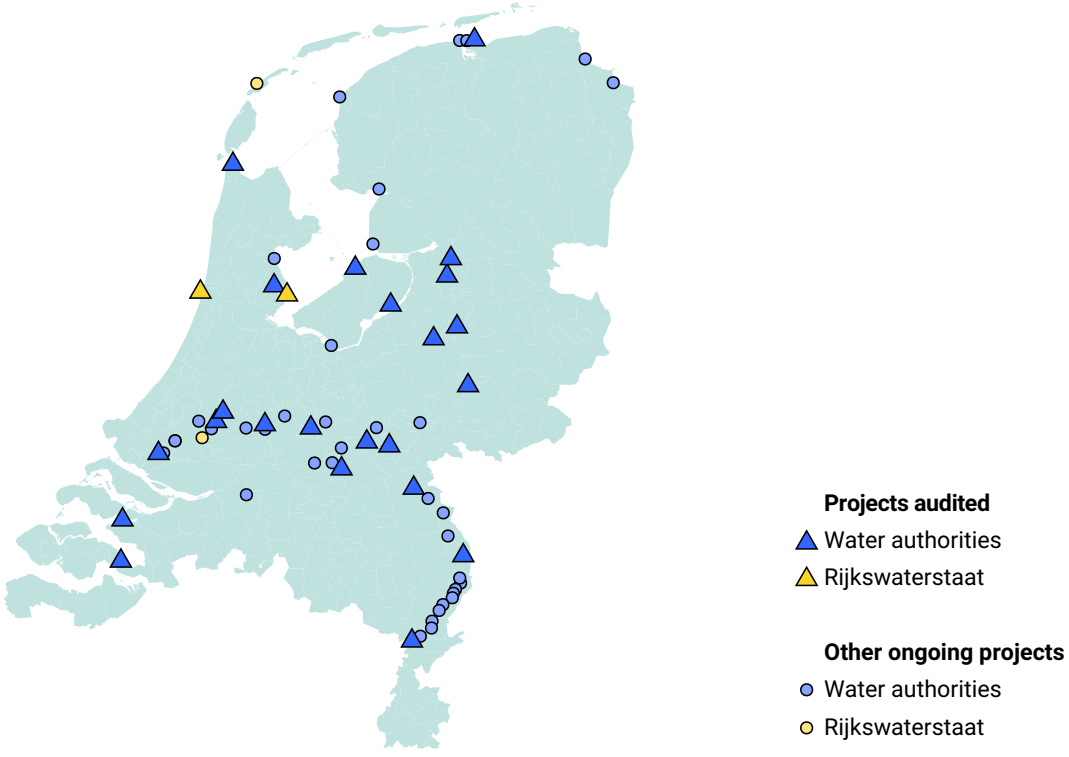
We investigated how the minister had designed multilevel safety into his policy to protect against flooding from the main water system. We also asked how the policy was implemented *in practice*, i.e. in dyke reinforcement projects.

The focus on the minister's dyke reinforcement policy reflects his claim that the policy is based on risk analysis and elements of multilevel safety. Furthermore, the minister has statutory tasks and powers to reinforce dykes and he invests a lot of time, money and effort in doing so. For a proper understanding of multilevel safety it is also necessary to consider the coherence and coordination of the dyke reinforcement policy and the policy on other flood safety options, such as river widening, coastal management, spatial planning and crisis management (see also § 2.2). We therefore investigated whether the minister adequately applied multilevel safety in his dyke reinforcement policy as part of his wider flood safety policy.

Our key audit question was: **Does the Minister of I&W apply multilevel safety adequately in his flood safety policy and his policy to reinforce primary water defences?**

We investigated the minister's policy and looked at how it was put into practice. We analysed documents and interviewed parties involved in 3 projects spread across the country. In addition, we studied 22 of the 64 dyke reinforcement projects that were being carried out. In total, our audit covered 25 projects, equal to 40% of the number being carried out in 2022 (see map below). Owing to the scale of the map, some projects overlap. A detailed methodological description is presented in appendix 3.

Figure 2 *Location of audited and all other dyke reinforcement projects in 2022.*



2.5 Organisation of this report

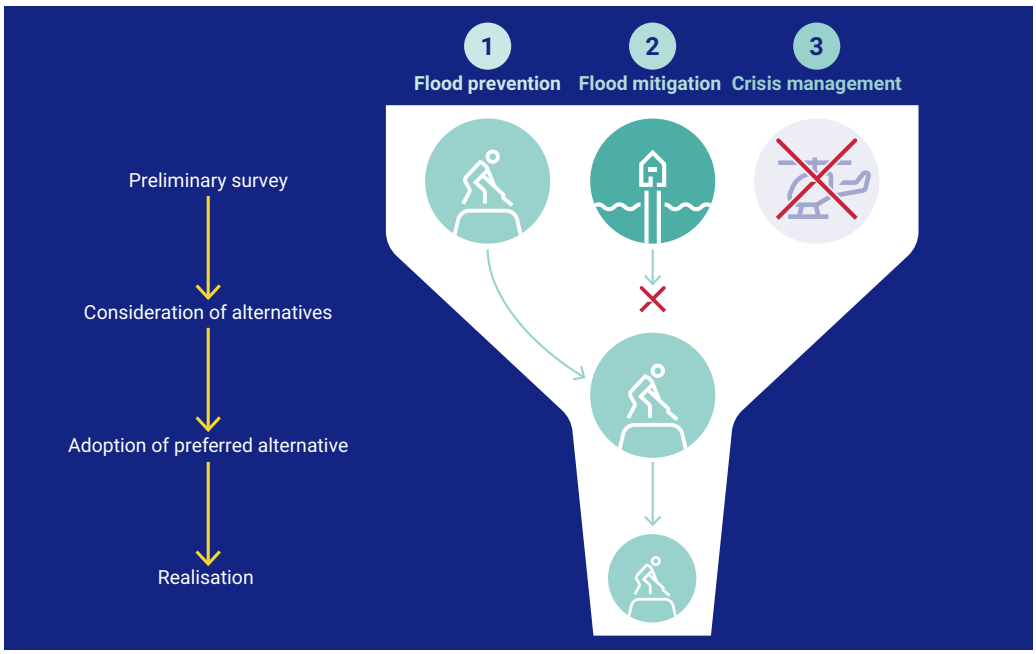
This report begins by describing how multilevel safety is applied in practice in the dyke reinforcement projects we investigated (chapter 3). We identify obstacles to multilevel safety that are due in part to the Minister of I&W's policy. Chapter 4 looks at the policy and the minister's oversight in more detail. Chapter 5 presents our conclusions and recommendations. Chapter 6 contains the minister's response to our draft report and our afterword.

3. Multilevel safety rarely applied

3.1 Introduction

In this chapter we discuss the results of our audit of multilevel safety measures in dyke reinforcement projects. We studied the files on 25 dyke reinforcement projects, including 3 that we investigated in greater depth. Our audit covered 40% of all dyke reinforcement projects carried out in 2022. Our main findings are summarised in figure 3.

Figure 3 *Implementation concentrates on dyke reinforcement*



Before we turn to the results, § 3.2 first describes the steps a dyke manager takes in a dyke reinforcement project and the options available for multilevel safety. We then describe the extent to which managers apply those options in their projects and identify success factors and obstacles.

3.2 Dyke reinforcement in practice

We noted in the introduction that statutory standards have been set for the strength of dykes. The managers of primary flood defences (water authorities and Rijkswaterstaat) must ensure that the dykes meet the standards by 2050. They accordingly periodically check the dykes they manage. If the dykes do not meet the standards, the managers have to reinforce them.

Managers take a series of steps before choosing a measure. They begin with a preliminary survey to identify all possible measures and then propose various alternatives. The proposals are discussed with residents, municipalities, provinces and other interested parties. A preferred alternative is chosen based on a series of criteria and the input from interested parties[5]. The preferred solution is then planned and implemented.

In some circumstances, managers may take other measures in addition to or instead of dyke reinforcement, provided the flood safety standards are met. They must weigh up reinforcement against solutions in the river, spatial planning interventions and crisis management measures. This is what we refer to in this report as 'multilevel solutions', in keeping with the Minister of I&W's use of the term 'multilevel safety'. The minister contributes financially to the managers' multilevel solutions provided they can convince him that they meet the statutory standards, are less expensive than dyke reinforcement alone and are feasible.

3.3 First step: thorough preliminary survey

Our file study revealed that managers often begin their projects with a thorough preliminary survey of all the options. They carry out area analyses and set up official and administrative working groups for Rijkswaterstaat, water authorities, provinces, municipalities and other stakeholders to share their thoughts. Most of the proposals (60% of those in the projects we audited) consisted of dyke reinforcement: managers named several options to raise or widen the dyke or suggested installing sheet piling in the dyke. The first multilevel solutions were also proposed in this phase.

3.4 Linkage opportunities rejected

If multilevel solutions are more expensive than dyke reinforcement or do not contribute directly to meeting the standards, managers can include them as 'linkage opportunities' in a reinforcement project. Linkage opportunities are measures in a reinforcement project that serve a secondary purpose, such as water management, construction of a cycle path or providing space for nature. They are not intended to meet the standard but can nonetheless increase flood safety. Municipalities that wanted to build new houses, for instance, also planned to create overflow areas after the dyke was reinforced, and some provinces developed the foreshore in front of a dyke as a nature area that also acted as a breakwater. Managers include linkage opportunities in their reviews. They have to be financed, however, by third parties, such as municipalities, provinces, the Minister of I&W (i.e. Rijkswaterstaat) and water authorities. As these financing arrangements cost more time, the high pace of dyke reinforcement prevents their implementation (see the example in the box below).

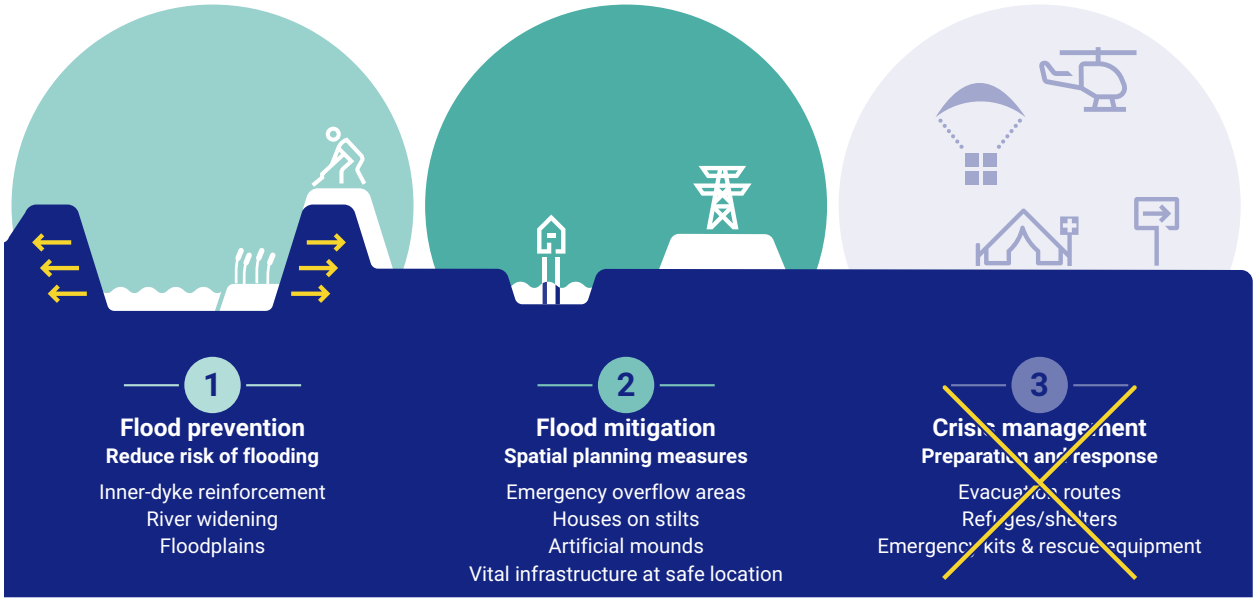
Example: missed opportunity to link river widening

During the preliminary survey, a water authority wanted to widen the river as proposed by the Minister of I&W. If Rijkswaterstaat widened the river, the water authority would need to carry out less reinforcement work. The minister, however, had not taken a decision on where and how the river should be widened. According to the water authority, waiting for a decision would unacceptably delay the dyke reinforcement project.

3.5 Crisis measures not considered

This section is summarised in figure 4: managers rarely consider crisis management measures in their initial review.

Figure 4 *Crisis management not considered*



Crisis measures rarely taken

Preliminary surveys considered crisis measures in just 2 of the 25 projects we audited (less than 10%). One of these projects was a pilot that had been studying multilevel safety for several years. The project manager had considered risk communication and several evacuation strategies, either instead of or in addition to dyke reinforcement. In the other project, the manager considered placing sandbags instead of reinforcing the dyke where it ran close to an industrial estate. In neither project did the manager actually take a crisis measure. The costs and benefits were uncertain, appropriate know-how was not available and responsibilities were not clearly defined (see the example in the box below).

Example: crisis measures difficult to implement

A manager thought investing in the risk awareness and self-reliance of residents was potentially cost effective. The costs amounted to 1% of the dyke reinforcement costs, but because not enough was known about the benefits of risk awareness, the return on investment was uncertain. Although the measure was less expensive, funding was not available under the flood safety policy or from the crisis organisation. Furthermore, agreements were not made on familiarising residents with the measures through, for instance, emergency exercises.

Safety regions rarely at the table

One of the reasons that many projects do not include crisis measures is the lack of involvement of safety regions. In the projects we examined, safety regions were rarely at the table when managers discussed their projects with external parties (see the example in the box below). This is a missed opportunity. In at least the first 72 hours of a flood event, residents are left to their own devices as emergency services cannot be everywhere at once. Safety regions can provide information through their websites on emergency kits that residents should have at home in order to survive the first days of a flood event. They can also advise municipalities on the design of flood-resilient homes (e.g. where to place power sockets) and crisis-proof spatial planning measures (e.g. how to plan evacuation routes and provide access for emergency services).

Example: safety region not involved in dyke reinforcement project

A safety region first heard about a dyke reinforcement project when a contractor working for the water authority asked it about safe routes to and from the construction site. The safety region would have preferred to have been involved at an earlier stage. '*Can emergency services enter an area if it is under 30 centimetres of water? If the water authority decides not to strengthen the dyke because the only things behind it are cows, the safety region still has to have a plan to evacuate the cows. […] All the decisions taken in the first level influence the next levels*.'

Contradictory public information

Another possible reason for rejecting crisis measures lies in the general public's poor grasp of flood risks. The Dutch have a lot of faith in their dykes but many do not know if they live in a high-risk area and are poorly prepared for a flood event (Snel et al., 2019; Kantar, 2020; Rode Kruis, 2023). The government provides information on flood risks via www.overstroomik.nl and other websites but the information is not consistent with information from the safety regions and crisis organisations. The message from the dyke managers (you are safe behind the dyke) is often at odds with that from crisis managers (you must be prepared for a flood). Dykes are prominent features in the landscape and reinforcement projects are an opportunity for dyke managers, municipalities and safety regions to provide local residents with an agreed and reliable risk assessment. The assessment should cover not only the protection afforded by the dyke but also the risks that dyke reinforcement cannot eliminate and how residents can prepare for them.

The Netherlands has chosen not to involve residents closely in flood safety policy. The United States shows that this need not be the case (see box below).

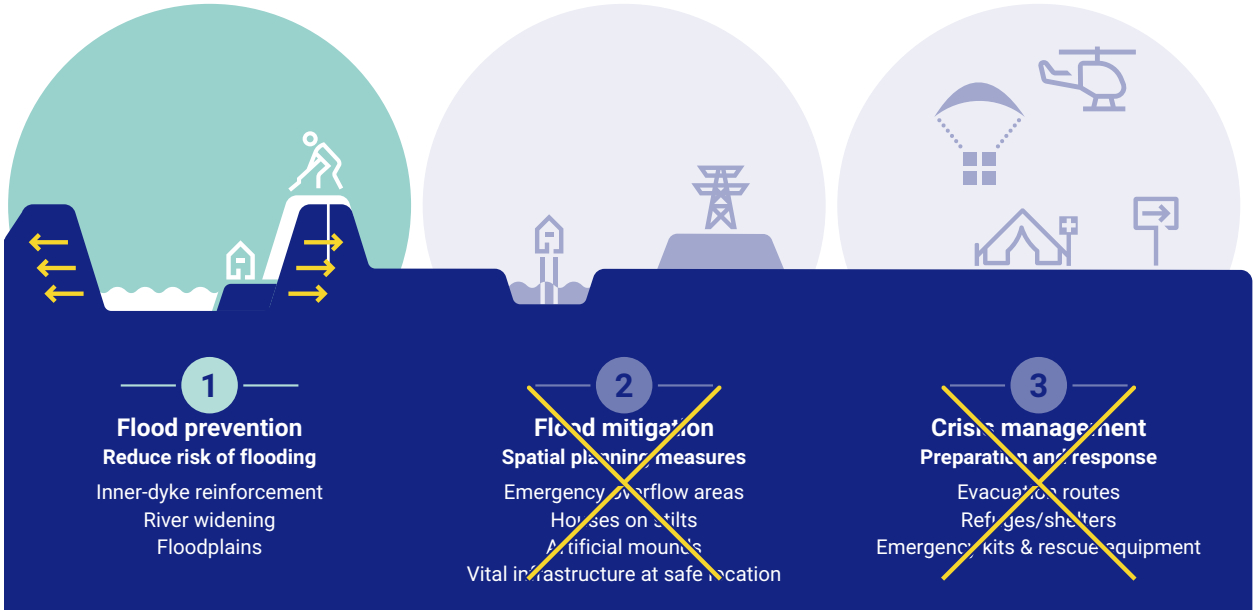
US: citizens involved in flood mitigation

The Dutch government provides some financial compensation for flood damage. The rules are set individually for each incident. The US has opted for a national flood insurance programme. It provides compensation to residents in high-risk areas. It also provides financial and other incentives for local authorities and residents to floodproof their areas and homes. The insurance programme has mapped out the flood risk in each area. In principle, the higher the risk, the higher the insurance premium. The maps determine what can be built or renovated in a particular area. To take part in the programme, a local authority must issue regulations prohibiting construction and renovation work in high-risk areas. For more information, see appendix 4.

3.6 Spatial mitigation measures quickly rejected

This section is summarised in figure 5: level 2 measures are quickly rejected during the managers' preliminary survey.

Figure 5 *Spatial planning measures rejected*



Spatial mitigation considered more often

In 7 of the 25 projects we audited, managers considered spatial planning measures in combination with dyke reinforcement. They thought, for instance, about creating temporary overflow areas to deal with overtopping or dyke failure. Other options included building or relocating houses on higher ground. In some projects, managers considered dividing the land behind the dyke into compartments based on feature lines in the landscape, such as regional dykes, hills or railway lines and roads. If a dyke burst, the flood waters could then be confined to particular compartment and time could be bought to evacuate people from densely populated areas.

But spatial mitigation measures rejected as too complicated

Our audit found that spatial measures were often rejected at an early stage of the preliminary survey. As they would be implemented on *land behind the dyke* where the province or municipality was responsible for spatial planning, managers were reliant on third parties for the measures' design, permits, implementation, management and maintenance. This reliance made the solutions too uncertain for the managers: they were tasked with dyke reinforcement but who could guarantee that the land behind the dyke would remain flood resilient? It is also difficult for dyke managers to estimate how spatial planning measures will help achieve the safety standard for the dyke. Little is known about this and there are no spatial planning standards. Moreover, there is little public enthusiasm for spatial solutions.

Managers are therefore often reluctant to propose spatial solutions and the measures often do not make it through the first assessment round. An example is given in the box below. In only 1 project we audited was a spatial solution part of the preferred package of measures. In it, construction work behind the dyke was restricted so that the land would retain its overflow function. Studies show, however, that such measures can be effective in the longer term (I&M, 2011; Van Buuren et al., 2015; Van Leeuwen et al., 2018; Advisory Task Force on Flooding and High Water, 2022).

Example: difficult spatial measure

A mix of housing, businesses and protected nature areas alternated with farms and water behind the dyke. Reinforcing the dyke would be a daunting challenge. The water authority suggested that raising the regional water defences and adapting the local water system would reduce the need for reinforcement. This multilevel solution offered spatial planning opportunities behind the dyke but its cost effectiveness was difficult to prove. The costs and benefits were uncertain, the permit process was complicated and the proposal was technically difficult.

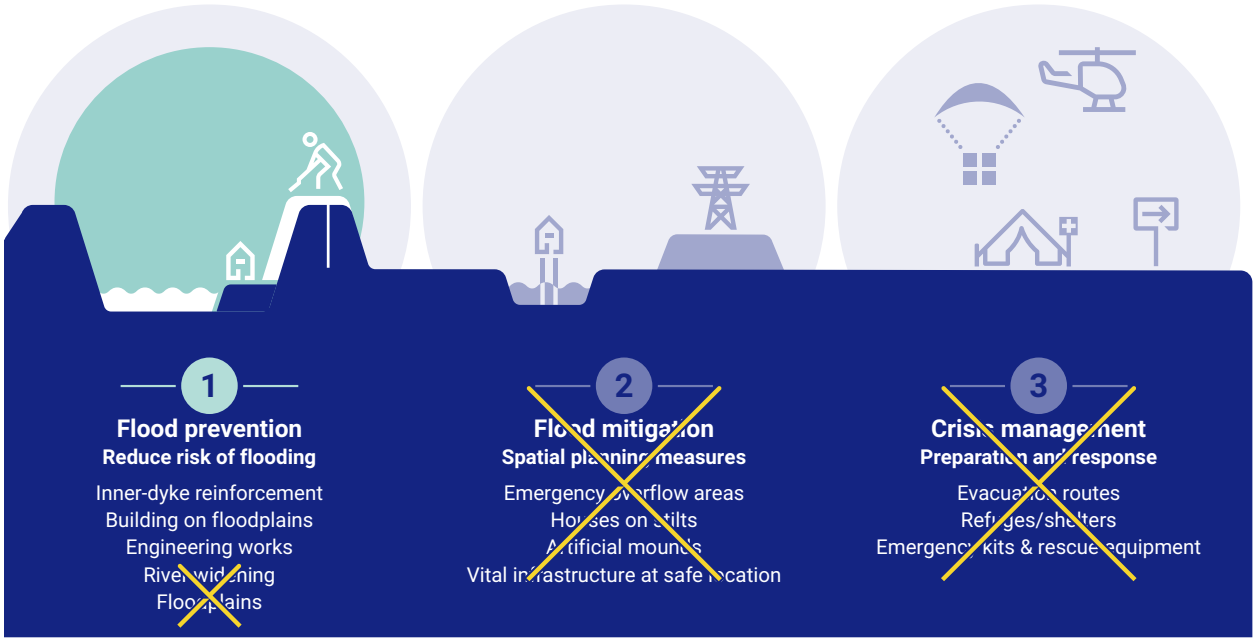
Spatial planning measures are considered chiefly in the area-based sub-programmes of the Delta Programme[6] (as at Rijnmond-Drechtsteden). The authorities working on a sub-programme take a wider view of all water-related challenges in their search for an integrated solution for area-based water management.

The minister recently decided that water and soil should play a more prominent role in spatial planning decisions (I&W, 2022b). At national level, however, his ambition is being frustrated. The Minister for Housing and Spatial Planning (VRO) and the provinces, for example, have approved plans to build many residential properties in low-lying areas in the west of the Netherlands where demand for housing is the highest (Delta Programme Commissioner, 2022b). Similarly, the government has designated Borsele as the preferred location for 2 new nuclear power stations, even though the site is at risk from the rising sea level and there is little space for dyke reinforcement (H2O Actueel, 2022). Some water authorities, however, are introducing grant schemes and issuing building regulations to protect areas behind the dyke from flooding.

3.7 Major interventions in the water system also rejected

This section on current water management practice is summarised in figure 6.

Figure 6 *Water system measures rejected, dyke reinforcement on the riverside*



Many studies of interventions in the water system

Although level 2 and 3 measures to mitigate flood damage behind the dyke are quickly rejected, dyke managers often consider interventions in the water system itself (i.e. the river) as a partial alternative to dyke reinforcement. Water system interventions range from bypasses (river connectivity to discharge flood waters) and the construction of locks and pumping stations to hold water upstream or increase discharge capacity, to building additional (double) dykes and relocating dykes further inland to give the river more room. Managers also consider smaller interventions such as raising the foreland (the landside area at the foot of the dyke) to serve as a breakwater, and temporarily reducing the discharge from the regional water system to prevent high water in the river.

Dyke managers have the know-how and powers necessary to carry out these measures. They can also make a good estimate of the costs and benefits, in part by entering river-based solutions in the Minister of I&W's calculation model. Managers can thus calculate the effect of interventions in the water system on, for instance, a river's capacity or flow profile fairly accurately.

Prohibitive cost of major interventions in the water system

Major interventions in the water system, however, are often rejected at an early stage during the preliminary survey. Managers think the measures are 'not promising' as early as the first assessment round because the costs until 2050 outweigh the benefits (see box below). If a measure entails construction of a new feature, such as an additional defence or a double dyke, it is rejected on account of the additional management and maintenance costs.

Example: major interventions in the water system rejected

Being part of a heritage site, the dyke in this example was difficult to reinforce. The water authority therefore sought a solution in the water system. It considered improving groundwater discharge, building an additional water defence and widening the river. None of these measures came through the water authority's feasibility assessment. The measures had to be combined with dyke reinforcement. By themselves they offered too little protection from flooding and the costs were prohibitive because the measures would be effective only if they were implemented on all the dykes along the river, not only on the stretch at the centre of the project.

The managers in 2 of the 25 projects we audited successfully combined large-scale interventions in the water system with dyke reinforcement. In 1 of the projects, we

saw how much time and effort the project cost the manager. Questions were asked about how exactly river-based measures contributed to dyke reinforcement. There was no blueprint for the administrative and financial agreements required between the water authority and Rijkswaterstaat, and the Minister of I&W had to issue a formal decree to adapt Rijkswaterstaat's standard for water defences before the solution could be implemented.

The rejection of major interventions in the water system is a missed opportunity. Studies have shown that river widening can significantly increase flood safety (Klijn, 2019; ENW, 2017b), and the Minister of I&W has long held the ambition of preserving room for the river and discouraging development in floodplains that prevents future river widening (V&W, 2006; I&W, LNV & BZK, 2023).

Managers make minor interventions in the water system more often. About 30% of the solutions we audited included minor river-based interventions (such as dredging channels and deepening floodplains) as well as dyke reinforcement.

3.8 Dyke reinforcement as the outcome

Simple solutions with a lot of public support
Managers are sensitive to local public support when proposing measures. Without it they often have to spend a lot of time and money dealing with complaints and procedures that delay the project. Public support is decisive for a smooth and successful project. Managers therefore often organise meetings to inform residents about a project and ask them to share their thoughts for or against the proposals.

No dyke in my backyard, reinforce the riverside!
When deciding whether to strengthen the dyke on the landside or the riverside, dyke managers often foster local support by combining dyke reinforcement with minor river-based measures. Stronger dykes take up more space, both in height and in width. Residents do not want dyke reinforcement to change their surroundings and prefer dykes to be reinforced on the riverside rather than on the landside where they live. Riverside reinforcement, however, reduces the room for the river. If this happens in many places, it can reduce the river's discharge capacity. Under the Minister of I&W's Large Rivers Policy, managers that nevertheless opt for riverside reinforcement are required to take compensatory measures in the water system (Rijkswaterstaat, 2023). The managers of the projects we audited often chose riverside reinforcement (18 of the 25 projects) in order to keep the public on board. In most, but not all, of these projects compensation consisted of deeper floodplains or channels.

Residents do not want high dykes

The height of dykes poses a similar problem. Residents do not want dykes to be so high that they cannot see the river. To keep residents on side, managers often (8 of the 25 projects) build a lower dyke that can be overtopped but will not burst, with additional strength compensating for lack of height. In accordance with the Minister of I&W's technical guidelines, the managers have to calculate how deep the water behind the dyke will be in a flood event, the economic losses and the feasibility of mitigation measures (Kennisplatform Risicobenadering, 2019, pp. 58-63). In only 3 of the 8 projects did we find an analysis of the potential economic losses and none of them considered flood mitigation.

In the Netherlands, public support for dyke reinforcement can be decisive. In Flanders, by contrast, flood safety comes first. It determines which projects go ahead and on what conditions (see box below).

Flanders: long-term area-based planning

Flanders has introduced spatial planning rules to prevent floodprone areas becoming even more vulnerable. It has identified 235 'signal areas'. These are undeveloped areas that already have a land-use designation (residential or commercial). They can also help prevent floods, for instance as overflow areas. Before a signal area is developed, the competent authority must assess the development's impact on the water system. The outcome can lead to a different land-use designation. If the designation is 'construction-free', parts of the area cannot be developed and must be used for a different purpose. If re-designated, compensation can be claimed for planning blight, with the Flemish government awarding the municipalities and provinces 60% of the compensation. For more information, see appendix 4.

Engineering works are popular

For the above reasons, 18 of our 25 project managers opted for sheet pile walls or another engineering solution. By installing sheet pile walls, the dyke need not be raised or widened as much, if at all. Some projects even considered glass or extendable sheet pile walls. Such engineering works, however, are the lowest of the Minister of I&W's preferences. They are expensive, difficult to inspect and may in future be harder to reinforce than 'green dykes'. If they do not meet the standard, moreover, the entire dyke may have to be rebuilt.

3.9 Multilevel safety: in practice, dyke reinforcement

This chapter looked at how multilevel safety is applied in dyke reinforcement projects. We noted that if a dyke does not meet the standard its manager undertakes a wide-ranging preliminary survey of river-based (level 1), spatial planning (level 2) and sometimes crisis measurement (level 3) measures. We also observed that these measures were often rejected very quickly and in practice managers opted for dyke reinforcement.

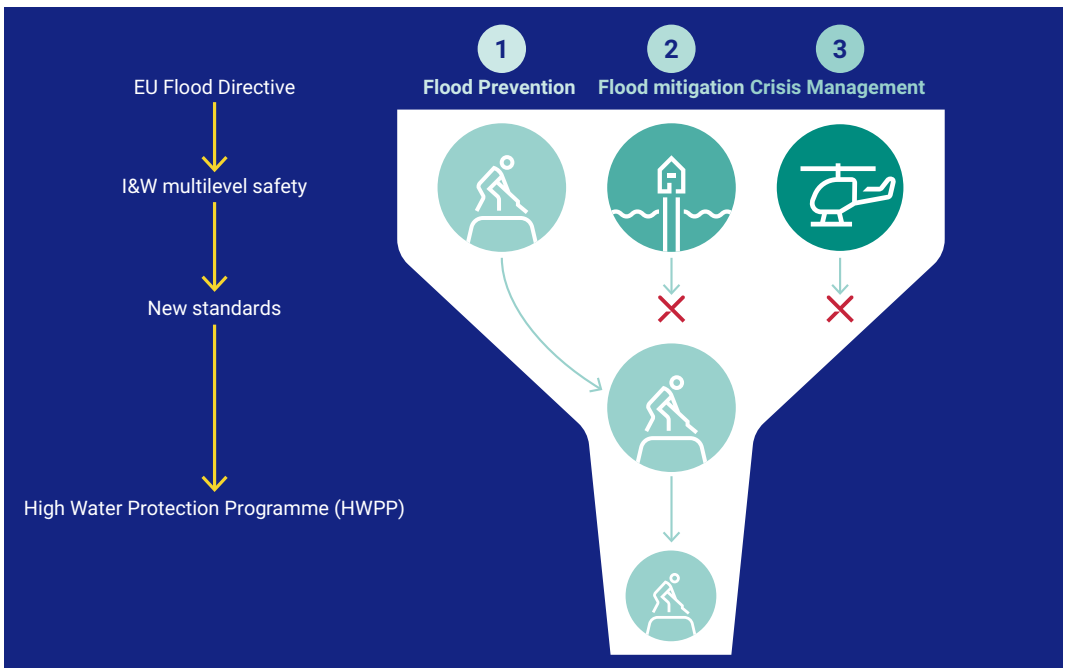
Measures beyond the dyke are rejected due to lack of knowledge, administrative and financial complexity and poor public support. Managers prefer straightforward, simple solutions that are widely endorsed. In practice, they accordingly tend to opt for dyke reinforcement. Dyke managers know this measure will meet the statutory dyke standard in 2050. Furthermore, they already have the requisite technical know-how and they themselves are usually the competent authority. In other words, they do not need to consult with provinces, municipalities or safety regions. According to the dyke managers, the public popularity of dyke reinforcement in the Netherlands means this solution harbours the least risk of delay and litigation. Multilevel solutions, by contrast, call for new know-how, new administrative agreements and new funding sources but above all do not enjoy public support.

4. Obstacles in flood safety policy

4.1 Introduction

We saw in chapter 3 that multilevel safety is rarely applied in dyke reinforcement projects. In this chapter we show that this is due in part to the Minister of I&W's flood safety policy itself. His interpretation of the policy results in a restrictive focus on dyke reinforcement at the expense of multilevel safety. This is shown in figure 7 and explained further in this chapter.

Figure 7 *Focus on dyke reinforcement in national flood safety policy*



4.2 New standards for primary flood defences

New standards based on EU risk strategy

The Netherlands set standards on the strength of primary water defences in the 1996 Water Act. They were revised in 2017 and must be met by 2050. The Minister of I&W based the standards on the European risk strategy: *'the standards are based on both the probability of a flood actually occurring and its consequences'* (Water Act Explanatory Memorandum, 2017, p. 3).

To revise the standards, each individual dyke section was assessed on the probability and consequences of flooding. Probability was based on the various ways in which a dyke could fail through overtopping, seepage or bursting. Consequences were based on the number of people and potential economic losses behind the dyke. To calculate the overall flood risk, the probability of a dyke section failing was multiplied by the risk of losses behind the dyke. This overall risk was then used to underpin the revised standards (see box below). In general, the higher the flood risk, the stricter the standard and the stronger the dyke has to be.

Calculation of standards for the primary water defences

The standards set for the strength of primary water defences are expressed as the 'maximum permissible flood risk'. A standard of 1:3,000, for instance, means that the average risk of a dyke failing and flooding the area behind it may not be greater than once every 3,000 years.

The standards are based on the Minister of I&W's flood safety ambitions (see § 2.2). He first considered *basic protection* and calculated the risk of flood fatalities behind each section of dyke, subject to a maximum of 1:100,000. Standards for the strength of each dyke section were based on this calculation. It was then asked whether *extra protection* was needed in addition to the basic protection in areas where many people could be affected, serious economic losses could be incurred or critical infrastructure could be damaged. The minister carried out a social cost-benefit analysis (SCBA) to determine whether an extra investment in dyke reinforcement weighed up against the value protected behind the dyke. The strictest standard for each section of dyke was laid down in the Water Act. In about 65% of the sections, the SCBA was decisive, basic protection was deemed sufficient in about a third of the sections.

The minister decided to translate the European Flood Directive's risk strategy into standards for just one solution, namely for dyke reinforcement. The decisions he

made have impeded the application of multilevel safety in the Netherlands. They are considered below.

Decision 1: standard for 2050

Recent IPCC reports warn about the accelerating pace of climate change. The Delta Programme 2021, for which the Minister of I&W has final responsibility, states, '*By now the urgency of looking further ahead, to the period beyond 2050, is indubitable. In many cases, the decisions and measures we are taking to realise the goals set for 2050 need to continue to perform their functions far beyond 2050*.' (I&W, LNV & BZK, 2020). The current standards do not allow for this urgency.

The minister has decided that all primary water defences must meet the new standards by 2050 at the latest. For flood safety purposes, this is a short time horizon. Sensitivity analyses carried out for the Minister of I&W found that the 2050 standards would provide inadequate protection if the sea level rose as projected and if more people lived and worked behind the dyke (I&W, 2020; ENW, 2023). But if the sea level has risen by 2 metres in 2100, it might be technically challenging to reinforce the dykes (I&W, LNV and BZK, 2021). According to ENW (2019), reinforcement may be financially and technically feasible but will have considerable spatial, ecological and social consequences. Dykes would be so high and wide that they would make impracticable demands on the available space.

In practice (chapter 3), managers are working hard to meet the standard by 2050. That is their statutory task. However, they are rejecting measures such as river widening and compartmentalisation dykes that can increase flood safety in the longer term, beyond 2050.

Decision 2: Standard for dykes not for areas

The European Flood Directive promotes the development of area-based protection strategies that combine preventive and mitigative measures. The UK set area-based flood safety goals before Brexit that are still in force (see box below), with flood resilience criteria that apply regardless of how an area is protected (by means of dykes, water system interventions, spatial mitigation measures or crisis management measures).

UK chooses area-based standards

The UK has mapped out flood zones to show where homes are at risk of inundation and so improve their flood resilience. Rules have also been set for newbuilds. If a development is planned in a flood zone, the local authority must first decide whether it can be carried out in a less vulnerable area where multilevel safety can be applied. The UK has also consciously chosen for the longer term, up to 2100. Furthermore, UK policy includes measures in and around homes, such as the fitting of flood doors and the relocation of boilers and power sockets. The policy is designed to limit flood damage and facilitate recovery work. For more information, see appendix 4.

In the Netherlands, the Minister of I&W has taken a different approach. He has analysed the flood risk per area (expressed as probability multiplied by consequences) but has set statutory requirements (standards) for primary water defences (dykes, dyke sections). This is a continuation of the 1996 policy.

The minister considered setting area-based standards, as in the UK, but nevertheless opted for a standard applicable only to the dyke. He gave the following reasons for doing so:

1. A standard for the dykes allocates specific administrative responsibilities to the minister and other authorities. Under the Water Act, the manager is obliged to meet the standard. Meeting an area-based standard would involve several authorities and their responsibilities are not laid down in law. According to the minister, this would provoke heated debate and delay dyke reinforcement.
2. A dyke standard can draw on existing knowledge about dyke failure mechanisms and dyke managers can accordingly take rapid, targeted reinforcement measures. No such knowledge is available for level 2 and level 3 measures. Developing a deeper understanding of these measures, moreover, is not feasible in the short term.
3. An area-based risk standard is not desirable from a social perspective because it says nothing about the strength of the dyke, which '*the Netherlands put their faith in*' (I&M, 2014, p. 19).

Decision 3: standard per dyke section

The standards set in 1996 applied to dyke rings: large rings of dykes built around an area. It is now known, however, that not all dyke rings have the same risk of failure and studies have shown that the consequences of flooding depend on exactly where a ring dyke fails (Royal Haskoning, 2014). According to the minister, setting standards

for individual parts of a dyke ring is a more accurate and lower cost investment against flooding (I&W, 2016). Parts of a dyke ring are referred to as *dyke sections* in the new statutory standards.

Focusing on smaller dyke sections, however, leads to the rapid rejection of measures that can prevent flooding on a larger scale, such as river widening. We also saw this in practice (see § 3.7).

Decision 4: social cost-benefit analysis
The Minister of I&W commissioned a social cost-benefit analysis (SCBA) to decide whether basic protection should be topped up with extra protection in areas with many potential flood victims and high losses. The SCBA compared the cost of flooding with the cost of reinforcement measures. If the protected value of an area was very high because there were many people and/or businesses, the SCBA decided that extra protection (in addition to basic protection) was cost effective. This was the case in about 65% of all dyke sections.

The SCBA covered only the cost of dyke reinforcement. It did not consider the costs and benefits of river widening, spatial planning or crisis management. The minister therefore cannot say that dyke reinforcement is always the most cost effective measure to meet the statutory standard, also not in the longer term heading towards 2100. The minister therefore does not have a comprehensive understanding of the costs and benefits of multilevel safety.

Decision 5: robust classes of standards
The standards for dykes are based on risk calculations (e.g. failure risks, fatality risks and economic risks). They are therefore surrounded by uncertainty and are only an approximation of actual flood risks. Partly for this reason, the minister ordered the standards into 6 large classes, each with a difference factor of about 3 (more precisely: the square root of 10). The classes are so large that the standards can be maintained even if 1 million new homes are built and the climate changes as predicted for 2050 (I&W, 2020a; ENW, 2023). Otherwise, the water authorities and Rijkswaterstaat would face ever-changing and unworkable challenges. According to the minister, the classes are ‘robust’.

In descending order, the classes have an upper limit of 1:100,000, 1:30,000, 1:10,000, 1:3,000, 1:1,000 and 1:300. An upper limit of 1:100,000 means that the average risk of a dyke section failing may not be higher than once every thousand years. An upper limit of 1:30,000 represents a higher average annual risk of flooding, because, for

instance, the SCBA found that there would be fewer flood victims and losses. The classes therefore express a certain level of safety.

These large classes impede the application of level 2 (spatial planning) and level 3 (crisis management) measures behind the dyke. In principle, managers must strengthen dykes that do not meet the standard. According to the minister, managers can meet the standard by taking measures in levels 2 and 3 instead of dyke reinforcement. The minister refers to this as 'smart combinations' (Water Act Explanatory Memorandum, 2017, p. 37).

Smart combinations must meet the required (statutory) safety level. If dyke reinforcement would provide a safety level of 1:10,000, managers must prove that level 2 and 3 measures would have a comparable outcome. As described above, this is difficult because there are no standards or key figures for levels 2 and 3. The large classes further complicate the use of these measures. If a dyke is not reinforced, it will be placed in a lower class and a legal amendment will be required (see also § 4.3). To meet the required safety level (1:10,000 in this example), compensation must be sought from level 2 and 3 measures. Several studies have concluded that the enormous package of measures in levels 2 and 3 is practically unfeasible and very expensive. As a result, level 2 measures (spatial planning) are often deemed to be cost ineffective (I&M, 2011; ENW, 2012, 2015 and 2016; I&M & EZ, 2017; TwynstraGudde et al., 2018). Smaller classes would make it easier to combine dyke reinforcement with level 2 and 3 measures.

We found that the large classes impede the application of multilevel safety in dyke reinforcement projects. Furthermore, the financial, legal and administrative framework for this kind of solution is uncertain. We explain this further in the next section (§ 4.3).

4.3 HWPP: sober and efficient dyke reinforcement

The High Water Protection Programme (HWPP) implements dyke reinforcement projects under the Minister of I&W's responsibility. The minister sets administrative, financial and policy frameworks for their implementation.

The Minister of I&W provides financial support for the HWPP from the Delta Fund. Rijkswaterstaat's dyke reinforcement projects are paid for directly from the Delta Fund. The minister has set up a grant scheme for the water authorities' reinforcement projects, with half the scheme being fed by the Delta Fund and the remainder by collective contributions from all 21 water authorities. The grant scheme covers 90%

of estimated costs. The remaining 10% and any additional costs incurred during implementation are borne by the water authority concerned. This is an incentive for the water authority to keep a tight grip on costs. In the HWPP, the water authorities and Rijkswaterstaat together administer the grant scheme and check whether grant applications meet the applicable conditions. The Minister of I&W approves both the HWPP programme plan and the grant decisions.

Sober and efficient

The HWPP's objective is '*to reinforce all primary defences soberly and efficiently by 2050 […] so that they meet the statutory standards*' (HWPP, 2019, p. 17). According to the minister, 'soberly' relates only to the cost of dyke reinforcement. In other words, everything that has to be done to have the dyke meet the standard by 2050. Measures outside this scope are not eligible for a grant. Such measures include dyke management and maintenance and the pursuit of water management, nature and spatial goals. 'Efficiently' means managers must opt for the lowest-cost solution and management and maintenance measures throughout the dyke's life cycle. The Board of Government Advisers has questioned this definition of efficiency: in the HWPP, efficiency concerns *'the scope of a project. Is the solution that seems the most efficient at a small scale and in the short term also [the most efficient] at a larger scale and in the longer term*' (Board of Government Advisers, 2020, p. 24). The text box below describes the results of the HWPP programme plan so far and the minister's accountability to the House of Representatives.

Progress of the HWPP programme plan and accountability for it

The HWPP's goals are to speed up and cut the cost of flood safety: the pace of dyke reinforcement must be stepped up from 25 to 50 kilometres a year as from 2020 and the costs must be cut from €10 to €7 million per kilometre. Planned and completed reinforcement work in 2020-2026 amounts to 28 kilometres a year. This is far short of the goal of 50 kilometres. Costs are rising: the new standards have increased the programme from 900 to about 1,500 kilometres. The Delta Programme 2023 confirms this picture and states that dyke reinforcement costs are rising and the Minister of I&W's next review of the HWPP should ask whether the budget available from the Delta Fund will be enough to cover future reinforcement work. On the launch of the HWPP programme plan in 2014, the Minister of I&W had budgeted €4.2 billion until 2028. In the 2023 budget, the budget had risen to more than €8.5 billion until 2036. Extrapolated to the end of 2050, the budget will amount to €13.8 billion. A further €12 billion (€13.1 billion after indexation) is estimated for the entire HWPP programme plan until 2050. In 2023, the minister will provide the House

of Representatives with a first, general description of the expected costs and the actual and planned dyke reinforcement work arising from the new statutory standards. This will be the first time the House receives a comprehensive description of the costs, results and expected remaining reinforcement work.

Focus on dyke reinforcement impedes measures in the water system (also level 1)
The HWPP programme plan favours dyke reinforcement at the expense of other measures. Grants can be awarded for multilevel solutions but the minister has not clarified when and on what conditions they will be.

Since the introduction of the new dyke standards in 2017, managers can apply dyke reinforcement funds to take alternative measures in the water system, such as river widening and the reinforcement of other water defences, but only if they save costs (dyke reinforcement costs must be avoided) and meet the statutory standard for the dyke section. To this end, the minister has established an 'alternative measures contribution'. We considered this contribution in 1 of the 3 projects we investigated in greater depth. We found that this solution costs a great deal of time (see box below).

Example: stronger Delta Work instead of dyke reinforcement

A river dyke was re-assessed against the new statutory standards introduced in 2017. The dyke needed to be strengthened and raised. It was very difficult to raise the narrow dyke because it was confined by ribbon development and several villages. If one of the Delta Works was improved, it was proposed, high tides and storm surges would not make their way up the river and the dyke would not need to be as high. This alternative was feasible and saved millions of euros in avoided dyke reinforcement costs. The solution was efficient but cost a lot of time and consultation and required an amendment of the law.

In the box above, the alternative measure was to strengthen a water defence located downstream from the dyke section. River widening was also proposed but the minister assumed it was not a cost efficient alternative to dyke reinforcement. His assumption was underpinned by a study that considered river widening only as a means to meet the statutory standard by 2050 (ENW, 2017a). The ENW (2017b) also concluded that a side effect of the new dyke standards was that less interest was being shown in river widening and other measures in the water system. Another study found that river widening increased flood safety *in the longer term* and *on a bigger scale* (Klijn, 2019). According to the Board of Government Advisers, moreover, river widening has many more benefits than just flood safety (Board of Government Advisers, 2020).

Application of level 2 and 3 alternatives unclear

As described in § 4.2, the minister's revision of the Water Act in 2017 enabled level 2 spatial planning measures and level 3 crisis measures to replace dyke reinforcement. The Explanatory Memorandum to the Water Act refers to this as 'smart combinations', describing them as '*a combination of spatial measures and/or contingency measures that together with the primary water defences provide the required level of protection*'. The minister has set conditions, however: smart combinations may be applied only in specific situations where dyke reinforcement is very expensive or socially disruptive, must cost less than dyke reinforcement and must be laid down in administrative agreements. As noted above, the Water Act includes standards for all individual dyke sections. According to the minister, smart combinations require an amendment of the act to change the standard for each dyke section (Water Act Explanatory Memorandum, § 9.5).

Internal memorandums on the HWPP programme plan (2022) refer to another approach to smart combinations that suggests that a new standard need not be set and the act need not be amended. It is therefore uncertain whether managers can take mitigation measures without lowering the standard but still receive a grant under the programme plan. We also found this in our audit (see box below).

Example: uncertain use of alternative measures from level 2 (spatial planning)

The dykes between 2 villages had to be reinforced. Solutions were sought to retain space to store water. An overflow area was considered as the dykes would then need less or only partial reinforcement. The municipality wanted to relocate 2 factories but it was uncertain whether a grant would be available under the HWPP programme plan. It was eventually decided to reinforce the dykes to meet the standard, the factories were not relocated and an overflow area was not created. The dykes were built slightly lower and the Minister of I&W will introduce rules on construction work behind the dyke in order to retain space for the water system.

Focus on 2050

The Minister of I&W has set a target date of 2050 for primary water defences to meet the statutory standards. According to the HWPP programme department, this is effectively a *short-term policy* for flood safety. The Board of Government Advisers (2020) had earlier found that the HWPP was small-scale and short-term in outlook. The Delta Programme Commissioner (I&W, LNV & BZK, 2020) and the Netherlands Environmental Assessment Agency (PBL) (2023) have also highlighted the need to look beyond 2050.

4.4 Limited oversight and limited knowledge building at I&W

Oversight and assessment of defences, no oversight of reinforcement

The Minister of I&W has delegated oversight of the primary water defences to the Human Environment and Transport Inspectorate (ILT). It oversees 2 aspects: management and maintenance of the primary water defences and assessment of the primary water defences against the statutory standards. Via the ILT, the minister does not oversee the choices managers make regarding multilevel safety and riverside reinforcement. The HWPP programme department does not consider these aspects either. The programme plan checks only that dyke reinforcement is sober and efficient and whether the standards will be in reach and within budget by 2050.

Knowledge building

The Minister of I&W has introduced significant changes in flood safety policy in recent years. The main changes relate to dyke reinforcement. The minister has invested in the development of new standards, the associated assessment framework and technical design guidelines. The minister regularly refines these detailed instruments as more knowledge is developed about dyke failure and subsequent reinforcement.

The minister is learning far less about multilevel safety. He has not yet formulated key figures for measures in levels 2 and 3, even though they have been under discussion since 2011 (I&M, 2011; WNG, 2013, Water Advisory Committee, 2014). In the meantime, more data are becoming available on the consequences of flooding and how they can be mitigated by measures in levels 2 and 3 (see, for instance, Climate Impact Atlas, and NKWK, 2022).

4.5 Focus on dyke reinforcement

In this chapter we have shown that the Minister of I&W may be seeking multilevel safety but his policy focuses solely on dyke reinforcement. He has chosen, for instance, to set statutory standards for dykes (not area-based standards), for individual dyke sections (not for water systems) and for 2050 (and not beyond). Furthermore, he has based the standards on only the costs and benefits of dyke reinforcement without considering the costs and benefits of multilevel solutions. The minister does not know whether dyke reinforcement is the most effective long-term option for multilevel safety. His policy is inadequately underpinned.

The minister allows measures beyond the dyke to replace dyke reinforcement but has not worked out an appropriate policy. As a result, multilevel solutions are quickly rejected because the limited instruments available to managers cannot determine whether they are more cost effective or not. Furthermore, the minister's financing arrangements for alternative measures are uncertain and managers do not know where they stand.

The minister does not oversee the multilevel safety decisions that managers make in dyke reinforcement projects. Nor has he developed standards or key figures for measures in levels 2 and 3.

5. Conclusions and recommendations

5.1 Conclusions

Extreme weather conditions are becoming more common. Floods can never be entirely ruled out and the Netherlands must be prepared for them. The Minister of I&W decided in 2009 to widen the scope of Dutch flood protection policy from preventive measures that reduce the risk of flooding to a multilevel approach that includes river widening and damage mitigation behind the dykes (by means of spatial planning and crisis management). This policy is nearly 15 years old but it is making slow progress. We investigated why.

The Minister of I&W makes too little use of multilevel safety

Our main conclusion is that the Minister of I&W has not put multilevel safety into practice. As a result, dyke managers cannot give multilevel solutions the consideration they deserve. In consequence, dyke reinforcement is the only measure actually taken. In the meantime, houses are being built in vulnerable locations and new nuclear power stations are planned on the Western Scheldt. This is increasing the vulnerability of the people behind the dykes and the potential losses. Instead of being widened to accept more water, rivers are being narrowed by dyke reinforcement. Residents are not prepared for the day the dykes overflow. This has consequences for citizens and businesses and, maybe more important, for future generations.

The minister has based his policy on multilevel safety. However, he has taken no steps to further develop this approach. Instead, he has opted for the more limited perspective of dyke reinforcement. He is not looking beyond the dyke.

Cause: policymaking and implementation stranded on dyke reinforcement
The minister's flood protection policy concentrates on dyke reinforcement. This is evidenced by new dyke safety standards implemented in 2017 and the supporting cost-benefit analyses that include only costs and benefits of different options for dyke reinforcement. The minister has thus taken the path of least resistance: the technical know-how necessary for dyke reinforcement is available, the targets and tasks are laid down in law and financing arrangements are well-known. Furthermore, dyke reinforcement is very popular among residents. By making use of existing know-how, policy instruments and administrative responsibilities, the minister is not gaining new insights, skills or opportunities for multilevel safety in practice.

The minister's oversight is also limited to dyke reinforcement. The Human Environment and Transport Inspectorate uman Environemnt and Transport Inspectorate (ILT) informs the minister about the progress of dyke reinforcement, but not about the extent to which and way in which multilevel safety is applied in dyke reinforcement projects.

The minister: look further ahead and with a wider perspective
The Minister of I&W's narrow focus on dyke reinforcement is not fit for the future. Dyke reinforcement standards are oriented to the year 2050. What are we going to do after 2050, when the country has subsided further, sea levels are even higher and the risk of high river runoff and extreme rainfall has increased? Do we keep raising, widening and reinforcing the dykes bit by bit because that's the easiest and cheapest option?

The minister argues that dyke reinforcement is cost efficient. But we conclude that the cost-benefit analyses supporting the national flood protection policy do not consider the costs and benefits of measures to better protect people and buildings behind the dyke. It considers only the costs and benefits of dyke reinforcement. Moreover, it does so with a view to meeting the dyke safety standards set for 2050. The minster has not looked beyond 2050 to explain why dyke reinforcement is more efficient, especially in the long term, than multilevel solutions.

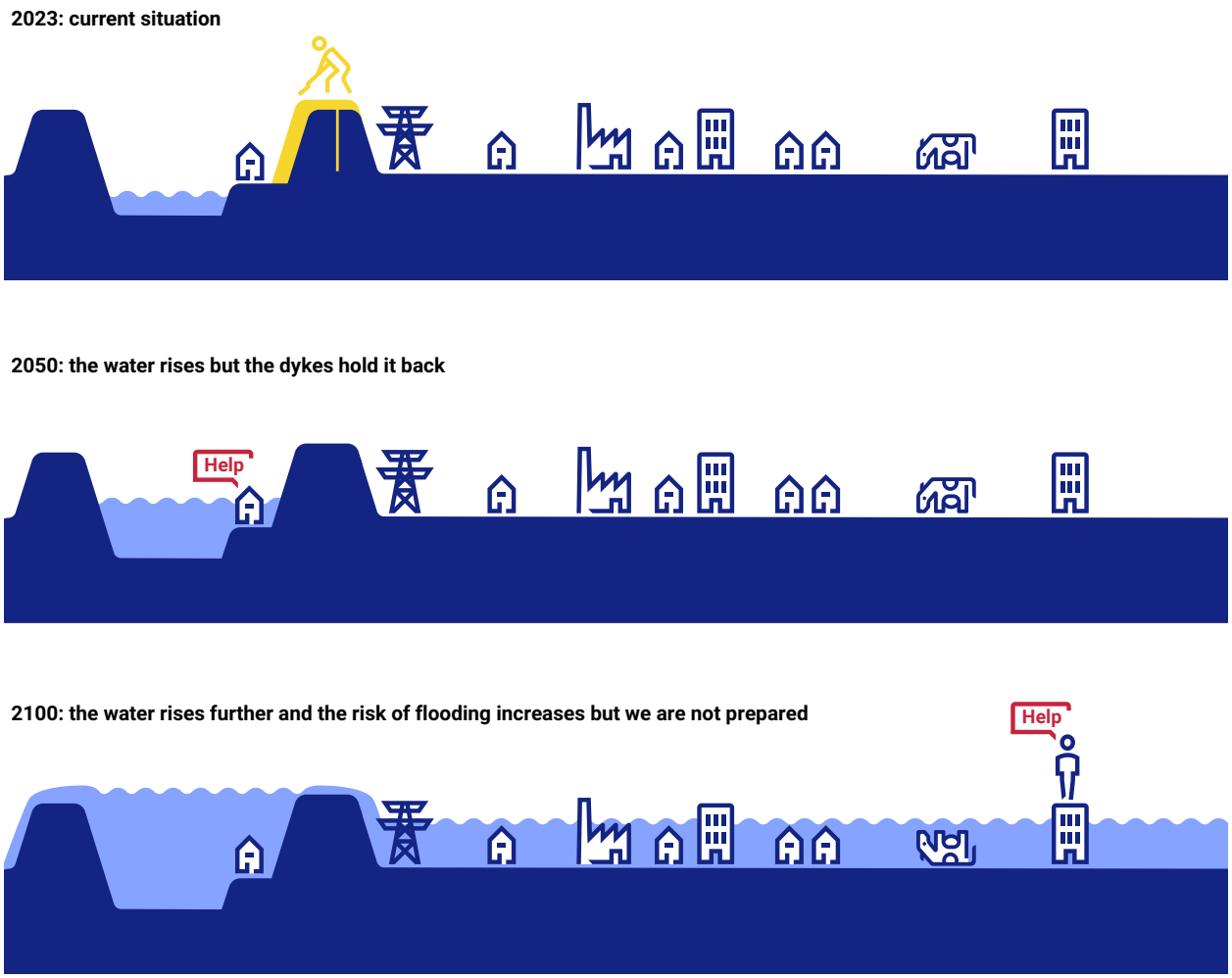
A practical plan is needed to make the most of multilevel safety. Other countries are already applying multilevel safety. Examples from Flanders, England and the United States are provided in this report. There are also multilevel safety initiatives in the Netherlands. For some time, experts such as the Chief Government Advisor on the Built and Rural Environment and the Delta Programme Commissioner have been calling for new, area-based targets based on water carrying capacity (Waterdemocraten, 2022, Deltacommissaris 2021a, 2021b, 2022a). A floodscapes project at Wageningen University, for instance, is studying broad, area-based flood protection solutions.

The Programmatic Approach to Great Waters initiated by the Minister of Agriculture, Nature and Food Quality (LNV) and the Minister of I&W to improve water quality in the Netherlands is also studying floodscapes in the foreland, dyke zone and hinterland.

Our audit shows that multilevel safety requires coordination among the various authorities and organisations responsible for flood safety: in front of, on and behind the dyke. This is turn requires targets and administrative and financial agreements. But the minister has not yet formulated a fitting policy.

Imagine, you now live in Gouda or somewhere else in the Netherlands that is protected by dykes and reinforcement is still the minister's only solution. What does the future look like for you, your children and your grandchildren? Will the scenario we described at the beginning of this report have become a reality? Will we be able to discharge water quickly enough? If fuse boxes have not been placed higher, electricity substations have not been raised above ground level, evacuation sites have not been established and people do not have emergency kits at home, the damage to homes and businesses will be incalculable. And more people will be affected because they live in vulnerable locations. See figure below.

Figure 8 *Future scenario:* **2023, 2050** *and* **2100**



5.2 Policy, execution and oversight recommendations

Floods cannot be ruled out but we can limit their impact. We therefore recommend that the minister make serious work of his own multilevel safety policy. This report is illustrated with examples from home and abroad showing that other options are available for multilevel safety. We advise the minister to look abroad for inspiration. We also make 3 recommendations regarding practical aspects of his own policy.

Policy: long-term solutions

The minister has set legal standards for flood protection but they apply only until 2050 and only to dykes. We recommend that the minister work out his own multilevel safety policy and supplement it with measures beyond the dyke. He must learn about the costs and benefits of multilevel solutions in the long-term as soon as possible.

He could include the long-term costs and benefits of drought, water quality and nature as well. This knowledge is needed now in order to take long-term decisions on flood protection.

Execution: clarification of multilevel solutions

The dyke reinforcement programme already allows water authorities and Rijkswaterstaat to opt for river widening, spatial planning and crisis management measures as wells as dyke reinforcement. However, the legal framework and financing arrangements for these alternatives to dyke reinforcement are complicated and time consuming. We recommend that the minister facilitate such measures by adapting the legal framework and financing arrangements to support the implementation of multilevel safety in practice.

Oversight: oversee multilevel safety

The Environment and Planning Act, which is due to come into force in 2024, will widen the ILT's oversight mandate. The minister could seize the opportunity to include multilevel safety in the ILT's oversight tasks to keep track of its implementation.

6. Response of the government and the Court of Audit's afterword

6.1 Response of the Minister of I&W

For a low-lying delta like the Netherlands, flood safety and how we achieve it cost effectively are of critical importance to the way we live and work, now and in the future. This is why it is a key policy priority and a major challenge to all partners in the water system. I&W bases implementation on a long tradition of flood safety with strong foundations in knowledge and experience and close cooperation among the partners.

The importance of multilevel safety was recognised in the first National Water Plan in 2009. It has since been continuously developed and refined. The National Water Programme 2022-2027 places multilevel safety in a wider context than just flood safety. It is also relevant, for instance, to waterlogging. Spatial planning and management must be adapted more widely to the consequences of climate change. Climate adaptation has an impact on many policy fields. The Minister of I&W coordinates the response to climate adaptation. Central government, municipalities, water authorities and provinces are all responsible for integrating climate-related measures into their policies, for making their assets, networks and urban and regional water systems climate-proof and for financing them. The Ministry of I&W has taken many approaches to encourage local authorities to make climate adaptations. The Court of Audit (NCA)'s insights are seen as support for policy on climate adaptation, flood safety and flood awareness.

Many studies have been carried out of multilevel flood safety. They conclude that primary water defences (level 1) are considerably more cost effective to manage

the flood risk from the main water system than level 2 (spatial planning) and level 3 (crisis management) measures[7], and, depending on specific local circumstances, can help mitigate the consequences.

Flood safety policy seeks to manage the risks of catastrophic flood events[8]. In 1953, waters several metres high covered a vast area of the Netherlands, claimed many lives and caused billions of euros' damage. In comparison with other countries, the Netherlands has many low-lying, densely-populated areas of high economic value and a historically-evolved and deliberately chosen high level of protection that is laid down in law. Reinforcement of water defences is quickly more cost effective than measures behind the dyke. That is why it is applied so widely in the national flood safety policy.

There are situations in which level 2 and 3 measures can be more efficient, for instance if a limited number of houses have to be protected or an area has a low level of protection. The 'smart combination' policy instrument can provide funding from the dyke account (of central government and the water authorities) for flood protection, provided reinforcement costs are saved. This instrument is also available for river widening and other measures; its effectiveness will be evaluated in 2024.
I agree with the NCA that the spatial design and planning of our country should take more account of flood safety interests. Not 'instead of' but in addition to protection by water defences. Climate change requires more judicious decisions on how we use and plan scarce space to be climate resilient and fit for the future.

A letter to parliament, Water and Soil as Guiding Principles, (parliamentary paper 27 625, no. 592) includes structuring options for specific decisions on where and how engineering work can take place, something the NCA rightly draws attention to. These choices are currently being worked out area by area with the responsible authorities. The Advisory Task Force on Flooding and High Water's recommendations following the flood events in Limburg (preliminary advisory report, March 2022; final report, December 2022) are relevant in this context.

The NCA recommends that multilevel safety be applied in regional and local water systems, where spatial planning measures such as those mentioned by the NCA can be particularly effective. Crisis management and cooperation with safety regions must also be improved. Furthermore, more must be done to increase flood awareness so that residents are better prepared, something the NCA also rightly notes. The Advisory Task Force's recommendations are currently being worked out.

The Minister of I&W is responsible for setting frameworks and standards to prevent flooding from the main water system, for providing frameworks and instruments to assess and design primary water defences and for overseeing their implementation. Assessing the water defences and deciding which measures are most appropriate to have a weak defence meet the standard are responsibilities and statutory tasks of the water managers. The primary defences (level 1) are managed by the water authorities and Rijkswaterstaat and supervised by the Human Environment and Transport Inspectorate (ILT). Spatial planning (level 2) and the water authorities' regional defences are supervised by local authorities. Safety regions (level 3) are supervised by the Justice and Security Inspectorate. It is therefore not necessary to extend the ILT's mandate to improve its oversight of multilevel safety, as the NCA recommends.

With regard to future-proofing, the NCA recommends looking beyond 2050, by when the dykes must meet the standards. I agree with this. Flood safety is indeed an unrelenting task, now and in the distant future; there is no end date. Flood protection from the sea, large rivers and lakes is founded on the long-term resilience of the primary defences. Flood safety policy is responsive and cyclical. Knowledge is continually being developed and applied, and a close eye is being kept on what awaits us in the long term. The Sea Level Knowledge Programme is studying potential consequences of the rising sea level for our country and for the current flood safety strategy. A range of long-term scenarios is being studied (sea level up to 5 metres higher) and avenues are being explored to prepare ourselves for the consequences, now and later. Flood safety policy will be adapted accordingly.

In view of the developments in flood policy, I can agree with the NCA's observation that the policy and the role of multilevel safety within it have to be clarified. This will be included in the forthcoming National Water Programme.

6.2 Court of Audit's afterword

The minister refers to the forthcoming National Water Programme as a vehicle to clarify the policy and functions of multilevel safety. We appreciate his undertaking. The minister has included multilevel safety in national flood plans and programmes – including those for the main water system – since 2009.

The minister shares responsibility for multilevel safety with many other parties. Coordination is therefore important. We expect the minister to take full responsibility

for steering policy, for ensuring and facilitating implementation and for overseeing progress towards his policy goals. The financial and administrative frameworks therefore need to be clarified.

The minister should also deepen and apply knowledge about the costs and benefits of measures other than the reinforcement of the primary water defences. Such knowledge – across the board and for the longer term, also beyond 2050 – is inadequate at present.

We share the minister's view that flood safety is an unrelenting task, without an end date. He calls to mind the long tradition of working on flood safety and the floods of 1953. We acknowledge this tradition. At the same time, we note that the climate is changing faster than expected, according to the IPCC. In brief, the minister decided 14 years ago that dyke reinforcement alone was inadequate and more had to be done beyond the dyke. However, too little is being done. We think this is a missed opportunity and a risk, especially for the more distant future.

Appendices

Appendix 1. Summary

Court of Audit's conclusions	Recommendations	Undertakings
The Minister of I&W applies multilevel safety inadequately in the national flood safety policy.	Develop area-based multilevel solutions for the longer term (2100) that meet the drought, water quality and nature goals.	Multilevel safety has been further studied and developed since 2009. Dyke reinforcement is the most cost effective measure to protect against flooding from the main water system. Multilevel safety can help mitigate the consequences but can be applied more widely and relevantly for regional flood events and climate adaptation. The letter to parliament, Water and Soil as Guiding Principles, includes structuring options that must ensure the Netherlands remains climate resilient and is future-proof by design.
Via the ILT, the minister does not oversee coordination between dyke reinforcement and other protective measures, such as river widening, spatial planning and crisis management.	The Environmental Act is due to come into force in 2024. It will give the ILT a broader oversight mandate. The minister should seize this change in the oversight mandate to improve his own oversight of multilevel safety.	The ILT oversees only the primary defences (level 1). It is therefore not necessary to widen its mandate to improve oversight of multilevel safety.

Court of Audit's conclusions	Recommendations	Undertakings
The minister's policy underpinning does not consider the costs and benefits of other protective measures.	The minister should start developing knowledge about the costs and benefits of multilevel measures, especially in the longer term, as quickly as possible.	There have been many studies of multilevel safety and there is abundant knowledge about it. The studies conclude that primary water defences (level 1) are many times more effective at managing the flood risk from the main water system than measures in level 2 (spatial planning) and level 3 (crisis management).
Multilevel safety calls for coordination between the many flood protection authorities and organisations, in front of, on and behind the dyke. New goals and new administrative and financial agreements are necessary.	The minister should clarify the legal framework and financing arrangements so that it is simpler to make the administrative and financial agreements necessary for multilevel solutions.	The instrument for smart combinations (in levels 2 and 3), which applies to river widening and other measures will be evaluated in 2024.

Appendix 2. Audit questions and standards

Audit questions

Key question: *Does the Minister of I&W adequately apply multilevel safety in his flood safety policy and his policy to reinforce primary water defences?*

Audit questions:

1. *Has the Minister of I&W thoroughly worked out and underpinned multilevel safety in the national flood safety policy and his policy to reinforce primary water defences?*
   a. How has the minister worked out the European Flood Directive's risk strategy in the national flood safety policy?
   b. Has the minister thoroughly worked out and underpinned the risk strategy in his policy to reinforce primary water defences?
   c. Is this policy consistent with existing responsibilities, tasks and powers, and has the minister checked that the necessary resources (financial, administrative, knowledge, etc.) are available to the parties concerned?
   d. Has the minister established an information management system to monitor the application of the risk strategy in the reinforcement of primary water defences and its financial and other consequences?
   e. Has the minister informed parliament of the considerations, decisions and uncertainties underlying this policy and of the financial and other effects for citizens and businesses?
2. *How do Rijkswaterstaat (RWS) and the water authorities apply multilevel safety when reinforcing primary water defences in the cases and files we audit?*
   a. Do RWS and the water authorities assess dyke reinforcement against other measures in level 1, and formulate their assessment and design decisions accordingly, and, if so, how?
   b. Do RWS and the water authorities assess dyke reinforcement against measures in level 2 (spatial planning), and formulate their assessment and design decisions accordingly, and, if so, how?
   c. Do RWS and the water authorities assess dyke reinforcement against measures in level 3 (crisis management), and formulate their assessment and design decisions accordingly, and, if so, how?
   d. To what extent and how are measures in levels 1, 2 and 3 reassessed during reinforcement projects if required by circumstances, and, if so, how?

3. *What factors support or impede the application of multilevel safety in the reinforcement of primary water defences in the cases and files we audit and to what extent are these factors due to the Minister of I&W's policy?*
    a. What factors support the application of the risk strategy in dyke reinforcement projects in the cases and files we audit?
    b. What factors impede the application of the risk strategy in dyke reinforcement projects in the cases and files we audit?
    c. To what extent are these factors due the Minister of I&W's policy and to what extent to external/contextual factors?
4. *Does the Minister of I&W have an insight into the application of multilevel safety in the reinforcement of primary water defences, does he evaluate his policy and adapt it where necessary?*
    a. Does the minister have an insight into the application of the risk strategy in the reinforcement of primary water defences, and into the opportunities and obstacles that arise?
    b. Does the minister evaluate the effects of his policy, change it if necessary to remove obstacles to the application of the risk strategy in dyke reinforcement projects and carefully underpin any changes?
    c. Does the minister account to parliament for the policy changes, the considerations, decisions and uncertainties underlying the changes and for their financial and other consequences for citizens and businesses?
5. *What can the Minister of I&W learn from countries such as the United Kingdom, the United States, Belgium and Sweden about the removal of obstacles to the application of multilevel safety in flood safety policy?*

Standards framework

The key question and audit questions 1 and 4 are opinion questions. We use standards to arrive at an opinion. Below, we explain how we adopted our standards. The other audit questions (2, 3 and 5) are descriptive questions. We did not adopt standards for them.

Key question

To decide whether the Minister of I&W 'adequately' applies multilevel safety, we investigated how he had worked out multilevel safety in the national flood safety policy. The policy gives priority to level 1 dyke reinforcement measures coordinated with other flood safety measures in levels 1, 2 and 3 (see § 2.2). We asked whether such coordination was due to the minister's policy.

We examined and assessed coordination in the minister's policy instruments: the Delta Programme, the policy on primary water defences and oversight of the policy field. We also examined and assessed the effect of policy in practice: are dyke reinforcement and other measures in levels 1, 2 and 3 coordinated as intended in dyke reinforcement projects? Finally, we examined and assessed whether the minister adequately oversaw the effects of policy: does the minister himself oversee whether his policy achieves or impedes the intended coordination? To answer the key question, we then expressed an opinion on the extent to which the minister adequately applied multilevel safety in his policy.

Audit question 1

To answer the first audit question, we examined and assessed whether the Minister of I&W had carefully underpinned his multilevel safety policy. To do so, we applied several basic standards that the Court of Audit uses in its performance audits. We assessed, for instance, whether the minister's policy was carefully designed, whether he had included multilevel safety in the national flood safety policy and his dyke reinforcement policy. We also assessed whether the policy was 'complete', whether there were 'gaps' and whether certain aspects of multilevel safety were underrepresented. We also assessed whether the policy was 'feasible', whether responsibilities were clearly allocated, whether all the minister's rules were clear and whether funding was adequate to achieve multilevel safety.

Audit question 4

To determine the learning capacity, we examined and assessed whether the minister regularly collected monitoring and oversight information regarding the application of multilevel safety in the reinforcement of primary water defences, and whether the minister analysed the information in order to understand opportunities and obstacles and steer policy.

Appendix 3. Audit methods

Our key question was, does the Minister of I&W adequately apply multilevel safety in his flood safety policy and his policy to reinforce primary water defences?

We take 'adequate' to mean has the minister carefully worked out and underpinned the principles of multilevel safety in his flood safety policy, and, as part of that policy, in his dyke reinforcement policy. We also asked whether the minister enabled the water authorities and Rijkswaterstaat to implement the policy in dyke reinforcement projects.

The audit consisted of 6 steps. Below, we describe the methodology in each step.

- *Step 1.* Policy analysis
- *Step 2.* Case study
- *Step 3.* Follow-up decision: case study or file study
- *Step 4.* File study
- *Step 5.* Analysis of I&W's learning capacity and responsiveness
- *Step 6.* International analysis

Step 1. Policy analysis

The objective of this step was to answer audit question : Has the Minister of I&W thoroughly worked out and underpinned multilevel safety in the national flood safety policy and his policy to reinforce primary water defences?

To answer this question, we analysed EU documents and national parliamentary papers and policy documents. We also interviewed the policy makers and policy implementers concerned. The topics discussed and the interviewees are listed below. To prepare for the policy analysis, we followed an introductory course on flood safety at Delft University of Technology. The course's aim was to give the audit team a basic understanding of the new flood safety standards and the assessment and design frameworks. In addition, we made a working visit to a water authority to gain a first impression of a dyke reinforcement project. Together with counterparts from the Flemish Court of Audit, we also made a working visit to the Deltares knowledge institute for water, where experts in a range of fields (standards, assessment, dyke reinforcement, climate change, multilevel safety) shared their latest insights with us and answered our questions.

Step 2. Case study

Objective

To answer audit questions 2 and 3, steps 2 to 4 of the audit addressed the practical consideration and application of multilevel safety in dyke reinforcement projects and the opportunities and obstacles that arose.

- How do Rijkswaterstaat (RWS) and the water authorities apply multilevel safety when reinforcing primary water defences in the cases and files we audit?
- What factors support or impede the application of multilevel safety in the reinforcement of primary water defences in the cases and files we audit and to what extent are these factors due to the Minister of I&W's policy?

We began with case studies in order to learn exactly how multilevel safety was considered in dyke reinforcement projects. Case studies were a suitable method for this audit step. We wanted to study the influence of I&W's policy frameworks (independent variables) on the consideration and application of multilevel safety in dyke reinforcement projects (dependent variables). This is not a direct relationship, however: we expected contextual variables (such as type of water defence, type of manager, project characteristics) to influence the risk strategy for dyke reinforcement projects. Case studies lend themselves well to problems where the relationship between independent, dependent and contextual variables is uncertain, as they can look at the problem in a natural context[9].

Selection of cases

We wanted to select 3 dyke reinforcement projects in the 2022 HWPP project book. The project book contains all ongoing and planned HWPP projects in and before the year in question and includes brief project descriptions. To be selected, a project had to satisfy **at least the following conditions**:

- Projects had to have started after 2017 and so be implemented in accordance with the new HWPP's policy frameworks.
- To gain a good impression of all aspects and phases of a dyke reinforcement project, projects had to have already undergone a series of steps in the dyke reinforcement process (assessment, planning, realisation, implementation).
- Projects had to include elements indicative of multilevel safety.

We did not want to select projects in which multilevel safety did not play a reasonably meaningful role, such as projects where only the dyke's revetment had to be reinforced. Conversely, we did not want to select projects that were piloting multilevel safety (such pilots have been carried out since 2011) because they specifically pursue multilevel solutions. Our ambition was to study the success factors and obstacles to multilevel safety in a typical reinforcement project.

We then selected projects to provide the **maximum variation of contextual variables**. We wanted to better understand the influence of contextual variables on the relationship between national policy and the consideration and application of multilevel safety in dyke reinforcement projects but we did not know in advance which variables would be the most influential. To obtain the variety we sought, we used the following selection criteria:

- spread across type of dyke manager: RWS and water authorities;
- spread across type of water defence: sea defence, river dyke, engineering works;
- spread across protection level (6 classes);
- spread across the Netherlands (west, north, east, south);
- spread across sparsely populated and densely populated areas (on the assumption that level 2 measures have more added value in sparsely populated areas and level 3 measures in densely populated areas).

We categorised all the projects in an Excel file in accordance with the above criteria and then selected 3 cases.

Data collection

We used the following documents to analyse the cases:

- HWPP project files;
- the dyke managers' project files;
- the ILT's oversight files.

For each case we held interviews with:

- the dyke manager;
- the municipality;
- the province;
- the safety region;
- the HWPP project supervisor.

Analysis

We analysed the cases by means of **process tracing**: we walked through all steps a dyke manager has to take in a reinforcement project and asked how and where multilevel safety was considered. The audit team worked in pairs on the case studies. We regularly shared our findings during the analyses so that the analyses would be comparable and consistent.

Step 3. Follow-up decision: case or file study

The case studies had 2 aims. Firstly, we wanted to gain an insight into why multilevel safety was applied or rejected in dyke reinforcement projects. Secondly, we wanted to determine what information could be found where in the files. We could then take decisions on the further progress of the audit. We had roughly 2 options:

1. file study;
2. additional case study.

Option 1 (file study) had a number of benefits. Quantitative analysis of a representative sample could draw a nationwide picture of why multilevel safety was applied or rejected in dyke reinforcement projects and the associated opportunities and obstacles. As the Netherlands Court of Audit, we are the only independent party to have access to the HWPP files and so draw such a nationwide picture. The dyke reinforcement files, however, had to contain information on why multilevel solutions were applied or rejected. Our case studies accordingly asked what information was in the files and what was not.

To this end, we compared the information we obtained from the files and interviews for each case study. We concluded that the files contained enough information on why managers applied or rejected multilevel safety *in a project,* but contained only partial information on the reasons for or against multilevel safety *outside the project*. The information covered spatial planning, crisis management and other flood safety initiatives taken by municipalities and safety regions. The information is interesting because it indicates where initiatives can be combined with dyke reinforcement. But it is not essential to answer our key question on the dyke reinforcement policy. As a file study could draw a nationwide picture of why multilevel safety was applied or rejected in dyke reinforcement projects, we decided to carry out a file study. We considered the information on multilevel safety in combination with dyke reinforcement in the discussion of the results of the case studies and the results of the file study.

Step 4. File study

Objective

The objective of the file study was to paint a nationwide picture of the consideration and application of multilevel safety in dyke reinforcement projects, and the practical opportunities and obstacles.

Project selection

Our case study found that multilevel safety was considered mainly in the initial phase of a dyke reinforcement project: the preliminary survey. In this phase, managers weigh up measures and select their 'preferred alternative'. They then work out the technicalities and tend to reject multilevel safety. We therefore decided to include projects in our file study that **had at least come through the preliminary survey and that already had a preferred alternative**. According to the 2022 HWPP project book, there were 64 such projects in 2022.

To select **representative** files with the widest possible **spatial and administrative variety**, we selected 2 projects at random (to be **representative**) for each manager (water authority or RWS, for spatial and administrative spread). Not all water authorities were carrying out 2 HWPP projects with a preferred alternative; some were carrying out 1 project and some none. As a result, not all water authorities were represented in our file analysis (Amstel, Gooi en Vecht, De Dommel and Hunze en Aa water authorities were not represented) and only 1 project was analysed for some water authorities. We subsequently found that 1 of the projects we had selected did not satisfy our minimum conditions. We eventually selected 25 projects for the file study, about 40% of the total population.

Data collection

The case studies had provided us with a good picture of the files that contained information of relevance to our audit. We used the following source documents in our file analysis:

1. The dyke managers' **preliminary survey reports**. These reports describe the reinforcement work proposed during the assessment round, the measures considered and their assessment. The managers sometimes wrote separate reports on each step in the process.
2. **Environmental impact statement.** In some cases the environmental impact statement numerically underpinned the consideration of measures.
3. **Assessment report + assessment table** of the grant decision for the preliminary survey and the planning phase. The HWPP project supervisors record whether the chosen package of measures satisfies the programme's sober and efficient criteria.
4. **Additional documents** describing the development/consideration of promising alternatives and the preferred alternative.

5. We also requested documents on the HWPP's *entry assessment***.** They include the considerations in the early phase of a project, when, according to the respondents in our pilot cases, a very wide-ranging survey is carried out. The project approach/ entry assessment, however, was applied for only 1-2 years and was not available for the projects we selected.

Data description

The managers in the reinforcement projects we selected considered a total of 237 'promising measures'. 128 of them were included in 'promising alternatives' and 58 were part of the 'preferred alternative'. However, these absolute figures do not tell the whole story. Some water authorities first assessed individual measures and later combined the most promising ones in a single package (alternative). Others worked from the outset with combined packages of measures, with measures being rearranged to make the alternatives 'more promising'.

Coding analysis

We used coding to analyse the files. We applied **open coding** to the minutes of the case interviews to identify recurring and important axial themes. We clustered the themes and labelled them in order to code the project files. We could then determine whether the themes in the case studies were also present at a larger scale (i.e. nationwide) or were case-specific.

We used Excel for the coding. We tested and refined the coding scheme in a series of rounds. We coded the first 6 files according to the four-eyes principle so that the auditors agreed with each other and supplemented the case studies with additional criteria. The other files were coded by a single auditor.

The final coding scheme comprised 2 parts. In the first, we described the measures that managers considered, whether the measures were level 1, 2 or 3, and how managers assessed them against the following criteria:

1. Investment costs: investment in land, engineering work, foreland, etc. – land solutions are relatively inexpensive.
2. Management and maintenance costs: calculated over a period of 100 years and discounted on a life cycle cost (LCC) basis – these are significant costs for the water authorities.
3. Total project costs: management, maintenance and investment costs – in principle based on LCC.
4. Manageability: is the measure simple to maintain, does the water authority have convenient access to it, does it need frequent maintenance, by whom?

5. Nature and environment: what are the consequences for nature and the environment, both during and after implementation? The consequences are sometimes assessed only during implementation and sometimes over the long term.
6. Public support: what do local residents want and think?
7. Spatial integration: how does the measure fit into the rest of the landscape? A high dyke is conspicuous, a wide dyke costs land.
8. Extendable: can the measure be extended in the future or not? Of importance when considering, e.g., a dyke or sheet pile wall.
9. Administrative and permit burden: does the measure require a lot of administrative consultation with many parties and/or require additional permits, e.g. in Natura 2000 areas.

We determined whether each criteria was assessed positively, neutrally or negatively or was not assessed during various phases of the preliminary survey: filter 1 (promising measures), filter 2 (promising alternatives) and preferred alternative. For each file, we used the assessment information contained in documents on the preliminary surveys, the chosen preferred alternative, the environmental impact statement, the HWPP assessment reports and written communication between the HWPP, the water authority and RWS.

To account for variations in the water authorities' assessment scales (on a 3, 5 or 7 point scale or a textual assessment), we opted for a 3 point scale: positive, neutral or negative in the colours green, amber and red. Nuances were categorised as very positive or less negative. Our first 3 criteria relate to cost. The files did not disclose costs consistently. Sometimes, only investment costs were available because management and maintenance costs were the same in all cases. Sometimes only total project costs were available without a breakdown. That is why we used 3 criteria.

We analysed this information in part **quantitatively** with the aid of a pivot table. The key questions in the quantitative analysis were:

1. In general, on what criteria were rejected measures/packages assessed more negatively than the chosen preferred alternative?
2. What percentage of the promising measures/packages included measures from 1 or more levels of multilevel safety other than dyke reinforcement?
3. What percentage of the measures in the preferred alternative consist of 1 or m ore levels of multilevel safety other than dyke reinforcement?
4. On what criteria were multilevel measures/packages assessed more negatively than the chosen preferred alternative?

The second part of the coding scheme was *qualitative*. We collected information on the possible success factors and obstacles to multilevel safety in each project. For each file, we also briefly described whether and how managers applied multilevel safety and the decisive factors for the preferred alternative. We analysed this information qualitatively to identify why multilevel safety measures were taken or rejected and to explain the results of the quantitative analysis and the case studies. We thus reconstructed the success factors and obstacles to multilevel safety in dyke reinforcement projects and traced them back to the Minister of I&W's policy wherever possible.

Step 5. Analysis of I&W's learning capacity and responsiveness
In the fifth audit step we analysed whether the Minister of I&W analysed the effect of his dyke reinforcement policy and whether he adapted his policy if necessary. This step answered audit question 4: Does the Minister of I&W have an insight into the application of multilevel safety in the reinforcement of primary water defences, does he evaluate his policy and adapt it where necessary?

As part of this step, we also considered the answer to audit question 1d: Has the minister established an information management system to monitor the application of the risk strategy in the reinforcement of primary water defences and its financial and other consequences? In hindsight, it was more logical to answer this question in this step.

To answer these questions, we analysed the Minister of I&W's oversight of the application of multilevel safety, both in his flood safety policy and in the ILT's oversight of the management of primary water defences. We also analysed how the minister rendered account, financial or otherwise, to the House of Representatives.

Step 6. International analysis
The aim of the sixth and final step was to understand how other countries removed the obstacles to multilevel safety that we had found in dyke reinforcement projects, and so answer audit question 5: What can the Minister of I&W learn from countries such as the United Kingdom, the United States, Belgium and Sweden about the removal of obstacles to the application of multilevel safety in flood safety policy?

We selected the countries based on interviews with other supreme audit institutions that had also audited flood safety and interviews with policymakers with relevant

international experience. In the preparatory phase we contacted and talked to the supreme audit institutions of Flanders, France, the United Kingdom, Sweden, Germany and Turkey.

We analysed documents and policy critiques to gain a deeper understanding of the policy in each country or region we selected (the United Kingdom, Flanders and the United States).

Appendix 4.
Multilevel safety in an international perspective

Introduction

We note in several places in this report that the flood safety policies of the United Kingdom, United States and Flanders differ from those of the Netherlands and that multilevel safety is applied abroad. Below, we look a little more closely at their multilevel safety solutions.

United Kingdom: area-based standards

The United Kingdom opted for area-based standards that combine measures from levels 1 and 2. The policy objective is to better protect 300,000 homes from flooding between 2015 and 2021 (NAO, 2020). This Property Flood Resilience (PFR) policy includes measures in and around homes to reduce flood risk and flood damage, such as the fitting of flood doors and placement of boilers and power sockets at a higher level. PFR is intended to limit flood damage and accelerate flood recovery. Between 2015 and 2021, more than 80 PFR projects improved the protection of 1,700 homes (DEFRA, 2022).

Level 2 is an integral part of a new programme launched in 2021 that includes measures to make water defences (such as dykes and sheet pile walls) and the water system flood resilient, and applies PFR for flood resilient spatial planning.

To support PFR and improve flood protection, the UK has drawn up flood zone maps that show a property's flood risk. Rules are also in place to regulate construction work in flood zones. If, for instance, there are area development plans in a flood zone, the local authority must first determine whether they can be carried out elsewhere in an area that is not as floodprone.

The UK has consciously chosen for the long term: '*This strategy's long-term vision is for: a nation ready for, and resilient to, flooding and coastal change – today, tomorrow and to the year 2100*' (Environment Agency, 2022).

United States: national insurance

The Dutch government does not provide full compensation for flood losses. Loss compensation rules are set separately for each event. The US, by contrast, has set up a national scheme to compensate for flood losses: the National Flood Insurance Program (NFIP).

The NFIP was launched in 1968 with 2 policy objectives (Congressional Research Service, 2023). On the one hand, it insures residents in high-risk areas against flood losses. On the other, it provides financial and other incentives for local authorities and residents to make their areas and homes flood resilient. Local authorities can take out the insurance only if they meet certain flood resilience criteria, and the more flood resilient homes are, the lower the insurance premium paid by the residents.

The NFIP has mapped out area-based flood risks in order to calculate the insurance premiums. In principle, the higher the risk, the higher the premium. The maps also show what can be built of renovated in each area. To take part in the NFIP, local authorities have to issue regulations prohibiting construction or renovation work in high-risk areas, and restrict development in areas at risk of flooding once in 100 years (Arnell, 1984).

If local authorities take part in the NFIP, local home owners are obliged to take out flood insurance as a condition to receive a federally-backed mortgage. Without insurance, owners have no right to certain forms of flood relief. They can pay a lower premium if they take measures to limit flood damage.

Flanders: area-based long-term planning

Flanders, too, has introduced spatial planning rules for floodprone areas (Rekenhof, 2023). To prevent the areas becoming even more vulnerable, the Flemish government has mapped out 'signal areas' that have not yet been developed but already have a land-use designation (such as housing or commerce). These areas can also help prevent flooding, for instance by acting as overflow areas. In total, 235 signal areas have been designated, covering a total of 3,339 hectares. There are 3 strategies for developments in these areas:

1. development subject to stricter flood assessment;
2. re-designation in a new spatial implementation plan (RUP);
3. designation as a water-sensitive open space area (WORG).

In a flood assessment, the competent authority assesses a development's impact on the water system, taking account of future flood risks. The competent authority can also re-designate signal areas to prevent construction work. Areas can be re-designated in one of two ways: as part of a spatial implementation plan (RUP) or as a water-sensitive open space area (WORG).

In a RUP, development is prohibited until building regulations are issued on the spatial planning and permissible construction work in an area. At the beginning of 2022, 31 signal areas had been at least partially designated as construction-free RUPs. A construction-free designation means that parts of the signal area may not be built on and therefore must have another land-use designation. In a WORG, the area remains open space and the land-use designation is withdrawn. Only very limited, if any, construction work is permitted. Water management, nature conservation, forestry, landscape conservation, farming and recreation are secondary functions in a WORG. No signal areas had been re-designated as WORGs in 2022.

In the case of re-designation, an application can be made for compensation for planning blight. The Flemish government can award municipalities and provinces compensation for up to 60% of the planning blight. No grant applications for re-designated signal areas had been made by mid-2022.

Appendix 5. Abbreviations

BZK	Ministry of the Interior and Kingdom Relations
EFD	European Flood Directive
ENW	Flood Safety Expertise Network
HWPP	High Water Protection Programme
I&W	Ministry of Infrastructure and Water Management
I&M	Ministry of Infrastructure and the Environment
IPCC	Intergovernmental Panel on Climate Change
J&V	Ministry of Justice and Security
LNV	Ministry of Agriculture, Nature and Food Quality
PBL	Netherlands Environmental Assessment Agency
RWS	Rijkswaterstaat
UvW	Dutch Water Authorities
V&W	Ministry of Transport and Water Management
VRO	Ministry for Housing and Spatial Planning

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Appendix 7. Endnotes

1 We define a flood as 'the temporary covering by water of land that is not normally covered by water'. This is the definition given in article 2 of the EU Flood Directive. Several other definitions are used in the Netherlands. The Water Act reserves the term to the temporary failure of a primary water defence resulting in fatalities or substantial economic loss (section 1.1). For the risk maps, the Minister of I&W specified this as at least 1 fatality or losses or more than €20 million – regardless of whether or not the flood was due to the failure of a primary water defence (I&W, 2018). We learnt from interviews that water managers often used the definition in the Principles for High Water Protection: 'a flood is an average water depth in at least 1 area or district with the same 4-digit postcode of more than 0.2 metre that causes social disruption'. As these definitions are inconsistent, we use the European definition.

2 The terms 'dyke' and 'primary water defence' are used interchangeably in this report. Primary water defences are the defences (dykes, dams, locks, etc.) that protect us from floods from the sea and the large rivers and lakes. The Minister of I&W is responsible for adopting the policy and standards for primary water defences. Dykes have also been built along smaller rivers. They are known as 'regional water defences'.

3 A series of major engineering works (dykes, dams, locks, sluices and storm surge barriers) to protect large areas of the Netherlands from flooding.

4 Safety regions are public bodies that organise regional cooperation to deal with emergencies, disasters and disruptions of public order. There are 25 safety regions in the Netherlands.

5 Managers deal with this differently in each project. Sometimes there are 2 assessment rounds, sometimes 5, and the criteria can differ from one round, project and manager to another.

6 The minister has transferred implementation of water management in the Netherlands, including multilevel safety, to the Delta Programme. This programme is implemented jointly by the Minister of I&W and local authorities. It consists of 3 parts: the Delta Programme on flood safety, the Delta Programme on fresh water and the Delta Programme on spatial adaptation.

7 See, for instance, ENW advisory report 'A Sober Look at Multilevel Safety', Planning area test, Delta Programme: rivers (water-resilient construction)

8 National Water Programme 2022-2027, flood safety.

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