

# PRINCIPLES OF PROFESSIONAL INSPECTION



REPORT

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13

Guide to Organizing Inspections

PRINCIPLES OF PROFESSIONAL INSPECTION  
GUIDE TO ORGANIZING INSPECTIONS

PIW

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# SUMMARY

The Flood Defense System Inspection Guide consists of three parts: the organizational part, the technical part, and the standard inspection plan. This document represents the organizational part of the guide. It offers management-level staff, responsible for organizing and conducting inspections of flood defense systems points of reference in drafting (parts of) an inspection plan.

## **SUBPROCESSES**

The inspection process comprises four subprocesses: observation, diagnosis, prognosis, and operationalization. These subprocesses are all described in this guide, which also discusses the structure and organization of the processes and how they may be optimized.

## **INSPECTION PLAN**

The subprocesses and the organization of inspections are further detailed and laid down in the Inspection Plan, the medium for the improvement of inspections. The Inspection Plan can be drafted per subprocess, with a more detailed elaboration for the primary and regional flood defense systems, or per category of flood defense systems, in which the subprocesses are discussed.

The drafting of the Inspection Plan takes place in four phases: preparation, establishing the baseline situation, determining the desired situation, and drafting an improvement plan. The focus lies on determining the desired situation, in which the inspection objectives, types of inspections, and the planning are specified.

## **QUALITY**

Various quality standards are available for the organization of inspections and the results. The most important quality-determining factors are the training and experience of the inspectors. Each subprocess is characterized by its own training and/or experience requirements.

A well-functioning control system contributes to the quality of the inspection process. The choice in hardware and software is a key element and strongly depends on the type of organization and the area to be controlled. A correct data structure for the inspection results in, for example, IRIS defense systems, and makes it easier for information to become available.

## **REPORTS**

With the help of reports, the controlling authority, management, and board are informed about the inspection results and the ensuing consequences. The control reports are both detailed and practical in nature, and form the basis for the overview reports to the controlling authority and the board.

## **FOLLOW-UP MEASURES**

Based on the reports, follow-up measures and actions for improvement are formulated. It is important for the completion of the inspection cycle that the progress of these actions is being monitored.

Reports may be used for communicating the inspection results on the website or via the media.

### **TESTING**

Inspections are an important part of the essential information required for the safety tests of the primary and regional flood defense systems, both for components of the technical test and in drafting the control assessments.

### **OUTSOURCING**

Inspections are increasingly being outsourced - entirely or in part - to private enterprises. The Inspection Plan allows the coordinator to have a systematic overview of the inspection steps, which enables him/her to determine, which components of the inspection may be outsourced and what are the respective requirements (quality, data).

### **LEGAL ASPECTS**

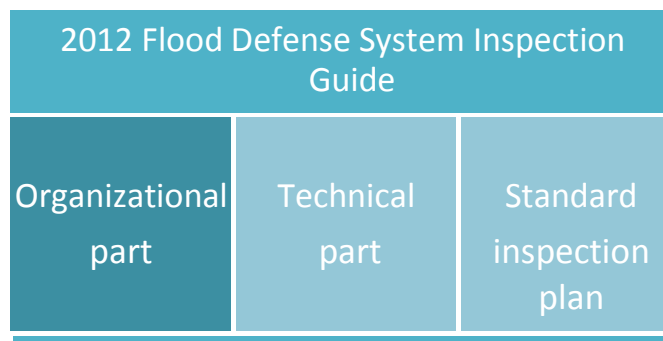
The consequences resulting from the ruling in the case of the quay breach in Wilnis are of significance in the set-up of inspections of the flood defense system.

# OVERVIEW OF THE 2012 GUIDE

The 2012 Flood Defense System Inspection Guide, hereinafter referred to as the 2012 Guide, consists of three individual parts (see Figure 1):

- The organizational part - this part - which describes the organization of inspections and the place of inspections within the controlling authority;
- The technical part, which describes the technical aspects of inspections;
- The standard inspection plan, which offers a guide for the drafting of inspection plans intended for internal use within the organization.

FIGURE 1 STRUCTURE OF THE 2012 FLOOD DEFENSE SYSTEM INSPECTION GUIDE



## TARGET GROUPS

The organizational part is targeted at the staff of the flood defense system administration who is responsible for inspecting flood defense systems. The technical part is aimed at the inspectors and the coordinators (flood defense system controlling authorities, inspection coordinators), and the staff conducting observations of the flood defense systems. The standard inspection plan serves as a tool for drafting inspection plans. Table 1 shows the objectives and target groups for each section of the 2012 Guide.

TABLE 1 OVERVIEW OF TARGET GROUPS AND OBJECTIVES OF THE GUIDE

Part	Target group	Objective
<b>Organizational part</b>	process managers policy-makers and coordinators	Description of the place of inspection in the control process of the flood defense system controlling authority Description of the organization of inspections
<b>Technical part</b>	inspectors coordinators	Technical foundation of the inspection process
<b>Standard inspection plan</b>	coordinators	Format for drafting inspection plans for own organization

## APPROACH

The Guide offers clear and well-structured information about the organization and improvement of the inspections of flood defense systems. The 2012 Guide's approach is 'lean and mean'. The substantiation and other information can be found in the so-called VIW publications (see [www.inspectiewaterkeringen.nl](http://www.inspectiewaterkeringen.nl) or [www.stowa.nl/producten/publicaties](http://www.stowa.nl/producten/publicaties)).

## OVERVIEW - ORGANIZATIONAL PART

Chapter 1 describes the importance of inspections, the necessity to further professionalize them, the background to the 2012 Guide and the possibilities for a more effective control of the flood defense systems.

The positions of the inspections within the organization of flood defense system administrations are described in chapter 2.

Chapter 3 describes the drafting of the inspection planning (types of inspections, objectives, clients).

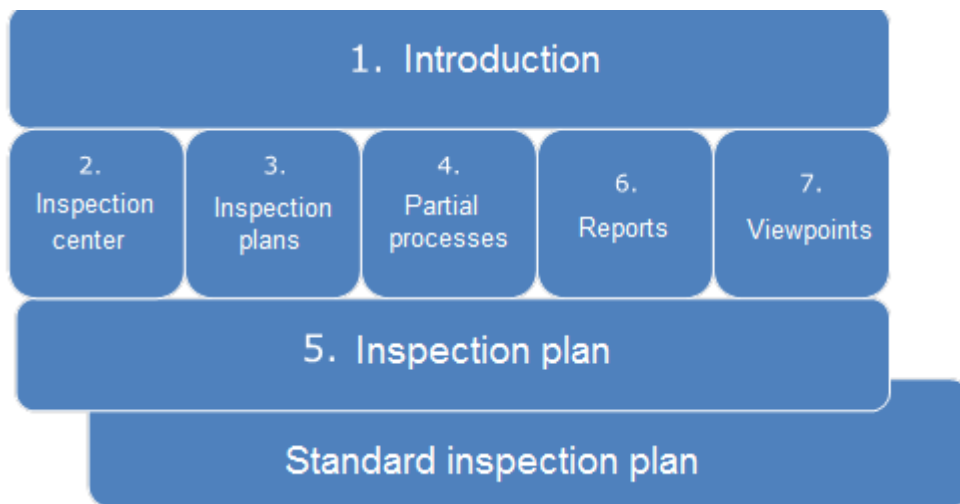
Chapter 4 discusses the inspection process, including alternative formats. This description forms the basis for all partners of the Guide.

Chapter 5 deals with the inspection plan itself and the quality of the execution. This chapter also provides practical information, including a step-by-step plan for setting up an inspection plan. The chapter is concluded with information about the options of digital management of the inspection results.

The reporting of the inspection results and the inspections to follow-up actions is stated in chapter 6.

Chapter 7 deals with the relationship of inspections and their environment and it describes the relationship with the safety tests of the primary and regional flood defense systems, aspects of outsourcing of inspections and the legal aspects pertaining to the inspections of flood defense systems.

FIGURE 2 STRUCTURE OF THE ORGANIZATIONAL PART AND ITS RELATION TO THE STANDARD INSPECTION PLAN



# A BRIEF OVERVIEW OF STOWA

The Foundation for Applied Water Research (STOWA) is the research platform of the Dutch water administrations. Participants include all administrations of groundwater and surface water in rural and urban areas, administrations of facilities for domestic wastewater cleaning and administrations of flood defense systems. This includes all water boards, higher water boards, wastewater treatment boards, and the provinces.

Water administrations utilize STOWA's service to perform applied technical, scientific, administrative, legal and socio-scientific research that is of a common interest. Research programs are established on the basis of assessments of the needs of the participants. Suggestions for research from third parties, such as research institutes and consulting firms are more than welcome. STOWA assesses these suggestions against the participants' needs.

STOWA itself does not carry out research, but let it run by specialized agencies. The studies are monitored by supervisory committees composed of participants' staff members, complemented by other experts, if needed.

The funds for research, development, information, and services are raised jointly by all participants. The current annual budget is about 6.5 million Euros.

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# 1

## PROFESSIONALIZATION OF INSPECTIONS

The control of flood defense systems is one of the government tasks, executed by the water boards and the Directorate-General for Public Works and Water Management. Both control about 3,200 km of primary flood defense systems and 14,000 km of regional flood defense systems. The objectives of flood defense system control are laid down in the Water Act and implemented in the provincial by-laws.

The control of flood defense systems has the objective of ensuring that the flood defense systems function the way they should, that is protecting the hinterland from floods. This objective has been laid down in the Water Act along with the security standards (primary flood defense systems) and has been further detailed in the provincial by-laws (regional flood defense systems). All control duties and activities are based on this, which includes the inspections of flood defense systems. Inspections are therefore an integral part of the control and maintenance of the flood defense systems and contribute to the upkeep of the flood defense systems, the enforcement of the water board by-law, and information provision for the safety tests.

### CAUSE FOR AND IMPORTANCE OF IMPROVING THE INSPECTIONS

Water does not keep itself to the borders of an area controlled by the flood defense system administration: it always finds its way to the weakest link in the dyked or quayed area. The control of flood defense systems is intended to detect and remedy those weak spots. Inspections play an important role in their identification and information about their existence.

The fact that flood defense system administrations have not always been successful in doing so was evidenced by the sudden and unexpected quay shifts in Wilnis and Terbregge in August 2003 (cause: dried peat embankments) and the subsidence of the embankment along the Juliana Canal to Stein in January 2004 (cause: leaking water pipes). These events, in combination with the results of the Dutch Safety Board about the quay breach near Stein (see Annex A) gave rise to the Directorate-General for Public Works and Water Management and STOWA to develop manuals for improving the inspections of flood defense systems.

Since that time, the need for further professionalization has increased:

- Within the framework of efficient water control, demonstrability and transparent actions of the flood defense system controlling authority are essential;
- An efficient deployment of individuals and resources, particularly in times of shrinking budgets, is required;
- The number of inspectors will decrease in the short term as a result of retirement;
- The ruling of the Supreme Court regarding the quay shift near Wilnis has made it clear that the owner/controlling authority is liable for damages resulting from failing flood defense systems, regardless of the efforts committed;
- Private enterprises are increasingly involved in carrying out the inspections.

## DRAFTING THE 2012 GUIDE

Substantial efforts have been made in the program improvement of Flood Defense System Inspections Program (VIW, 2004-2008). The Green Version of the Guide (2008) is one of the concrete results of these efforts.

In 2009, the next step in the professionalization process within the framework of Improvement of Flood Defense System Inspections program was taken, namely: the Professionalization of Flood Defense System Inspections program (PIW, 2009-2012). The underlying reason for the PIW program was that the introduction of structure to the inspections and linking inspections to the other control processes ('from traditional methods to professional processes') was not easy.

The knowledge of and experience in components of the VIW and PIW acquired by the many controllers, including interviews, area pilots, thematic pilots, have been incorporated in this 2012 Guide. It thus contains best practices of the inspection practice.

### 1.1 MANDATE AND SCOPE

#### MANDATE

The structure and execution of the flood defense systems inspection differs immensely at each controlling authority, because they have freedom to act as they see fit. This is because of the lack of guidelines for executing and recording inspections and the lack of national requirements set to the educational level of inspectors. Furthermore, the link of the inspections to the other control processes differs.

The PIW program does not have a mandate for imposing the structure and quality of inspections. Therefore, the Guide takes into account that the manner of execution greatly depends on the organization, which in its turn depends on the scope and physical characteristics of the area to be controlled, among other things.

#### SCOPE

The 2012 Guide is aimed at inspections of dikes and quays (primary and regional) that are regular and that can be planned. Inspections of constructions, dunes and inspections in special circumstances, such as drought, and (imminent) calamities do not form part of this Guide.

### 1.2 PROFESSIONAL INSPECTIONS LEAD TO MORE EFFECTIVE CONTROL

#### INCREASED EFFICIENCY

In order to professionalize inspections, the inspection process and the link to the other control processes are to be systematically detailed. This results in an overview of options for improvement, which must be prioritized. An increased efficiency is reached when these improvements are implemented.

Examples of improvements are:

- *Inspection process*: The manner of inspection, training of inspectors, recording data, planning inspections, reporting, feedback of results and follow-up actions of inspectors;
- *Link to the other control processes*: Data management and data exchange, relation to execution/improvement and testing.

## RISK REDUCTION

The flood defense system controlling authority (inspector, coordinator, manager, board) must be in control at all times. To this end, he must be able to demonstrate that the flood defense systems can function properly up to the standard load. The inspections of flood defense systems and the safety tests provide the flood defense system administration with the required information. If a flood defense system fails resulting in damage from flooding or possibly worse, the flood defense system controlling authority can demonstrate using the inspection and test results to what extent it has fulfilled its duty. Therefore, all data should be current, accessible, and reproducible.

### 1.3 FLOOD DEFENSE SYSTEM CONTROL IS CYCLICAL

The control cycle provides the framework within which the inspections take place. Figure 1.1 shows how the inspection, maintenance and testing cycles are related to each other: the data of the inspections feed the regular maintenance activities such as maintenance, license issuing and enforcement and the safety tests.

FIGURE 1.1 FLOOD DEFENSE SYSTEM CONTROL, WITH IN THE CENTER THE INSPECTION CYCLE (BLUE) WHICH PROVIDES INFORMATION TO THE MAINTENANCE CYCLE (GREEN) AND THE TESTING CYCLE (ORANGE)

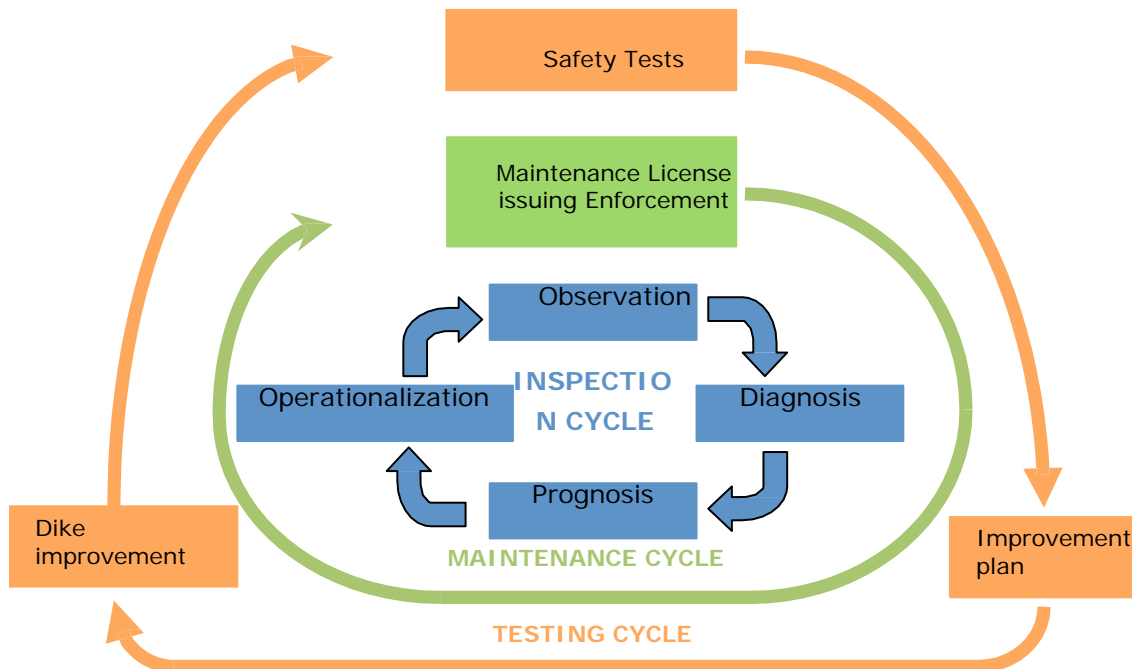


Table 1.1 describes the necessary information for the inspection per control process. Further elaboration depends on the category of flood defense system (function, location, and physical characteristics), the joint use of the flood defense system and the policy-related elaboration of the processes by the controlling authority.

TABLE 1.1 TYPE OF INFORMATION PER CONTROL PROCESS

Control process	Type of information
Maintenance, improvement	deviation observed: type of damage <sup>1</sup> ; scope of the damage; location, including indication on cross-section; severity; required repairs, including prioritization (directly, before or after storm season).
License issuing + enforcement	breaches observed: nature (license, water board by-law, lease, property); location (including indication on cross-section); severity (e.g., consequences for water safety, maintenance); required measures + prioritization (directly, before or after storm season). <i>Please note:</i> including check of shutting down activities of the primary flood defense systems in connection with storm season.
Safety tests	substantiation of technical and control assessments: long-term monitoring series; registration of specific damage linked to failure mechanisms (see also technical part).

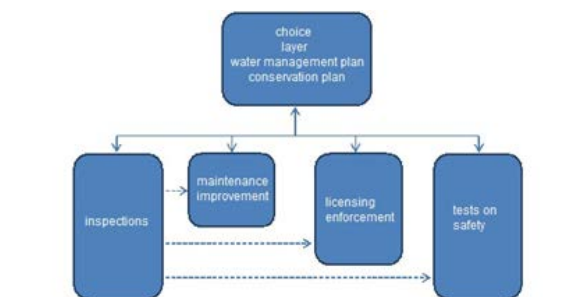
#### 1.4 INSPECTION PLAN AND OTHER CONTROL INSTRUMENTS

For the performance of its duties, the controlling authority has the following tools at its disposal (see also Figure 1.2):

- *Water board by-law*, in which the regulations of the water board have been laid down;
- *Register*, which documents the spatial and functional features of the flood defense systems, among other things. Together with the water board by-law, the register forms the basis for the performance of duties of the flood defense system controlling authority.
- *Water management plan*. This plan translates the national and provincial policy, legislation and regulations into the area controlled. It thus forms the basis for all management activities: inspection, license issuing, enforcement, maintenance and testing.
- *Maintenance plans* (Directorate-General for Public Works and Water Management), *flood defense system control plans* (water boards), in which the current state of the water-retaining structures and the planning of inspections and maintenance have been laid down.

The maintenance plan, inspection plan, license issuing and enforcement plans, emergency control plans and the safety tests support and further detail the control plans/maintenance plans.

FIGURE 1.2 RELATIONS OF THE INSPECTIONS TO THE OTHER MANAGEMENT ACTIVITIES



1 See also the Overview in the Technical Part

# 2

## INSPECTION PLANNING

### 2.1 FOUR TYPES OF REGULAR INSPECTIONS

The type of inspection and the frequency with which inspections are carried out throughout the year depends on the following factors:

- Category of flood defense system: primary (A, B, C), regional, other;
- Season in which the inspection is carried out;
- Type of open water: sea, lake, basin, foreland, river, canal, dry flood defense system;
- Type of load: high water, storm;
- Current strength of the flood defense system;
- Protected interest/level of the standard;
- Geographical spread of the components to be inspected;
- Accessibility and surroundings (urban, rural, nature reserve).

Season and category of flood defense system are the two most dominant factors:

- Season:
  - A detailed and systematic inspection of all flood defense system preferably takes place at the end of winter (March) due to limited covering;
  - During open season, regular maintenance work (mowing, pasture, fencing, joint use, and so on; all flood defense systems) must be supervised;
- Category of flood defense system:
- Primary flood defense system. Prior to the closed season, they are inspected in order to determine if the work to/near the flood defense system has been completed and if they are ready for the closed season. After the closed season, an inspection is performed to list any damages. This inspection preferably coincides with the annual inspection in which the current state of the flood defense system is mapped out systematically and in detail;
- Regional flood defense system. In view of the larger area and the lower standards, the inspection frequency of the regional flood defense systems is mainly limited to once a year.

The 2012 Guide starts out with the four principle types of regular inspections, as described in Table 2.1.

2 The traditional term "schouw" (survey) is interpreted differently by all flood defense system controlling authorities. This term has therefore not been included in the standard description.



**TABLE 2.1 STANDARD INSPECTIONS**

Type of inspection	Description
<b>Spring inspection</b>	A systematic and detailed inspection in which the current state of the flood defense system is determined at the end of the closed season.
<b>Summer inspection</b>	Check of (manner of execution and result of) maintenance work by contractors and maintenance debtors.
<b>Autumn inspection</b>	Check of completion of maintenance work and licensed activities and of determining the condition of the flood defense system prior to storm/high water season.
<b>Daily inspection</b>	Inspection throughout the year aimed at supervising (enforcement) and detecting damages.

The inspection planning also depends on the structure of the organization and the working methods of the controlling authority. Examples of the latter are:

- 1 Inspectors who are responsible for the entire control process, which means that they are frequently present at flood defense systems such as dike workmen who execute the mowing tasks and who are responsible for the supervision of pasture activities/ lessees;
- 2 Inspectors who are only responsible for observations. In that case, there is a planned presence at the flood defense systems;
- 3 Outsourcing inspections. The difference with version 2 is that no 'own' employees inspect the flood defense systems.

## 2.2 INSPECTION PLANNING IN TWO STEPS

The inspection planning is executed in two steps. First, the clients and their objectives are listed. Then, for each client it is determined what type of information they need and how often. In attuning the various objectives and the conversion into inspection types, the planning is optimized in terms of costs, frequency and level of detail.

### STEP 1: LISTING CLIENTS AND THEIR OBJECTIVES

The inspection clients determine objectives and thereby the data to be obtained (information and frequency). Potential clients and their objectives are:

- 1 Maintenance: efficient maintenance planning;
- 2 Enforcement: monitoring the enforcement of the water board by-law and register by the landholders;
- 3 License issuing: monitoring the enforcement of the license conditions;
- 4 Testing: determining the current state of the flood defense systems by checking them against the statutory or provincial standard.

In addition, there are clients at different level of abstraction:

- 1 Management aiming at optimization and professionalization of internal processes and products;
- 2 Board wanting to be informed about the current stability and functioning of the flood defense systems;
- 3 Communication informing landholders about the inspection and current state of the flood defense systems, often in special situations (e.g. emergencies).

Therefore, it is important to have knowledge of objectives and structure of the client's processes. Annex B describes how the objectives and the processes of the 'maintenance' and 'enforcement' departments may determine the inspection planning.

The required information for these target groups has been detailed in the technical part.

## STEP 2: DRAFTING THE INSPECTION PLAN

The clients' need for information (features of the flood defense system and frequency) should be linked to the inspection planning (types of inspections and frequency). Table 2.2 shows the result: an annual planning that is structured in such a way that all objectives of the clients are met with a minimum number of inspections.

**TABLE 2.2 LINKING THE TYPE OF INSPECTION TO THE OBJECTIVE**

Objective of inspection	Spring inspection	Summer	Autumn	Daily inspection
Systematic and detailed	X			
Determine damage				X
Inspection of maintenance		X	X	X
Enforcement	X	X	X	X

The Inspection Strategy Quickscan has been developed in the PIW program, which supports the establishment of the inspection planning. The Quickscan checks whether the total package of inspections meets the extent to which the organization wants to manage the flood defense systems under its control.

Using the model, it is possible to indicate for each flood defense system category how often per year the following inspection objectives must be met:

- Overall inspection for damages;
- Detailed inspection for damages;
- Monitoring maintenance;
- Supervision within the framework of enforcement of the water board by-law;
- Supervision within the framework of enforcement of the licenses;

An overview shows if the desired frequency are achieved based on the inspection planning selected. Furthermore, it is possible to gain insight into the costs and number of hours spent in the planning.

The model works based on the following data:

- The various types of inspections and the frequency with which they are performed;
- The costs and hours spent per type of inspection;
- The characteristics of the area (category of flood defense system and length);
- The desired frequency of each inspection objective and the manner in which the various types of inspections facilitate these objectives.

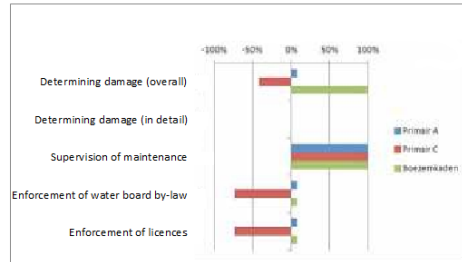
The Inspection Strategy Quickscan is available on the website

[www.inspectiewaterkeringen.nl](http://www.inspectiewaterkeringen.nl) (see Figure 2.1).

**FIGURE 2.1 A SCREEN SHOT OF THE INSPECTION STRATEGY QUICKSCAN THAT SHOWS TO WHAT EXTENT THE INSPECTION FREQUENCY LINKS UP WITH THE INSPECTION OBJECTIVES (PER CATEGORY OF FLOOD DEFENSE SYSTEM)**

**INSPECTION STRATEGY**

**STANDARD AND ACTUAL NUMBER OF OCCURENCES PER YEAR**



# 3

## THE INSPECTION PROCESS COMPRISES FOUR SUBPROCESSES

The inspection process can be divided into four subprocesses (see Table 3.1).

**TABLE 3.1 THE FOUR SUBPROCESSES OF THE INSPECTION PROCESS**

Subprocess	Objective
<b>Observation</b>	establishing, detecting and documenting certain features of a flood defense system
<b>Diagnosis</b>	processing the observed features so that insight is gained in the current state/situation of a flood defense system
<b>Prognosis</b>	determining the expected development of the quality of a flood defense system
<b>Operationalization</b>	defining and planning the desired follow-up actions

The subprocesses are discussed separately. By analyzing each subprocess and mutual relation separately, it becomes clear where the weakest links in the inspection process are and which choices and deliberations can be made to further professionalize the inspections of flood defense systems.

This does not mean that these subprocesses should be detailed separately in structuring the inspection. Experience has shown that these processes generally merge together; a separate detailing may come across as forced. For instance, a dike inspector, relying on his knowledge and experience, may make a diagnosis and a prognosis upon detection of damage (subprocess of observation).

Figure 3.1 shows that the execution of an inspection starts with the subprocess of observation. The primary course of proceedings is clockwise. Feedback regarding the preceding subprocess is possible from each subprocess.

**FIGURE 3.1 THE FOUR SUBPROCESSES OF THE INSPECTIONS OF FLOOD DEFENSE SYSTEMS**



### 3.1 OBSERVATION

#### OBJECTIVE

The objective of observation is to establish, detect and document certain features of a flood defense system.

#### VISUAL OBSERVATION

Visual observation is at the heart of inspections. A professional inspector can see the important features of the flood defense system at a single glance. However, it is uncertain whether or not these observations are identical with those made by his/her colleagues. After all, visual observations are mainly based on personal knowledge and experience and therefore are subjective. There is a good chance that two inspectors observe (and assess) one and the same damage situation differently based on their own knowledge and experience.

In order to make visual observations as objective as possible, it is important that the inspector is trained in recognizing and identifying the type of observation and that he has a reference framework from which he makes the observations. To this end, the Digiguide (*Digigids*) and Digiprior are being developed within the framework of PIW. Digiguide (*Digigids*) is a damage catalogue for sea dikes, dunes, river dikes and regional flood defense systems that shows the various levels of damage for each type of damage with the help of photographs. Digiprior is a method for giving meaning to detected damage in relation to the strength, stability and prioritizing.

#### OBSERVATION WITH THE USE OF TECHNIQUES

Observations are not limited to visual observations. Measurements are increasingly forming part of the inspections. This does not only concern the measurements of the height (spirit levels, laser altimetry, remote sensing, AHN2), but also measuring parameters in the flood defense systems. The latter is offering an increasing amount of possibilities thanks to the technological developments in sensor technology, among other fields, from the various *IJkdijk* and *LiveDijk* projects (see [www.ijkdijk.nl](http://www.ijkdijk.nl) for a current overview).

#### DATA

For the inspections that are aimed at the strength and stability of the flood defense systems, the following data are important:

- 1 Damage situation + classification (see Table 3.2). For a uniform determination of the damage situations, please be referred to the technical part and the Digiguide.
- 2 Detailed data: coordinates, location, size, amount, resolution (density of the damages per length unit or surface unit, e.g., number of molehills per 10 m<sup>2</sup>);
- 3 Characteristics of the surroundings: Situation, overview photographs, detailed photographs;
- 4 General data.

In addition to establishing damages, establishing other matters that may affect the functioning of a flood defense system, such as violations of the water board by-law, form part of inspections. Annex C contains examples of reference maps that inspectors use in the visual inspections at Rivierenland Water Board and Wetterskip Fryslân. Furthermore, a general reference framework has been developed and made available by STOWA and the Directorate-General for Public Works and Water Management. For more information, go to [www.inspectiewaterkeringen.nl](http://www.inspectiewaterkeringen.nl).

## DOCUMENTING AND PROCESSING DATA

The documentation of information may take place in two ways:

- *Analog or digital.* In this situation, the observations are documented on maps and forms in a standardized manner. The forms may contain standard values and instructions. At the office, the maps and forms are entered into a management system allowing to obtain an overview of the entire area of the flood defense system. Digital management systems used vary from simple Excel spreadsheets to advanced GIS systems;
- *Digital.* The digital documentation of observation is done using tablet PCs (preferably with GPS) on which an inspection program has been installed. To this end, Diginspection (*Digispectie*) has been developed within the framework of VIW and PIW. This software guides inspectors in an uniform manner through the documentation process of observations and works with standardized registration (location, features, scores and so on). A link to standardized damage catalogues such as Digiguide enhances the uniformity of observation.

The central processing of the data obtained in the field in a management system is relatively easy. Management systems may vary from simple databases to GIS management registers. A well designed management system is very valuable for optimal use of the digitally documented observations. A condition to using this working method is that the controlling authority - frequently - invests in equipment and software and that adequate ICT support is provided.

## OBSERVATION AND SAFETY

Of all four subprocesses (observation, diagnosis, prognosis and operationalization), observation is object-linked. One of the important features is the safety of staff that perform the observations and the safety of the environment where measurements may be cause of nuisance. For instance, for observations from helicopters or airplanes, licenses and minimum allowed flyover altitudes may be required.

### *Good instructions*

Staff performing observations at flood defense systems are obliged to execute their tasks within the health and safety regulations. They have to be recognizable and adhere to the rules pertaining to personal safety. Furthermore, the instructions should be clear and univocal, so that the inspections can be performed as uniformly as possible.

## NOTE

In practice, it frequently happens that the management system is, in fact, the collective memory of the inspectors. Disadvantages to this way of data management include:

- Making objective trend analyses is hard;
- The system is person-related and therefore not robust. For instance, there is a great risk of loss of data when the inspector leaves the organization;
- The (subjective) memory lapses in time.

## 3.2 DIAGNOSIS

### OBJECTIVE

The objective for diagnosis is to process data in such a way that insight is gained into the current state/condition of the flood defense system.

## DEFINITION

In making a diagnosis, the observed or measured values are compared with pre-determined limit values, such as minimum height, maximum number of molehills per surface area, or historical and area-related information as well as information from tests and other processes are used.

Questions that may come up in diagnosis include:

- Is there a pattern in the damage situation;
- Is the damage related to the design/choice in/of material;
- Is there a chance of repetition;
- Is it necessary to monitor the damage;
- Can the damage be temporarily and responsibly repaired;
- What does the damage tell you about the design or standard.

## SEPARATION OF OBSERVATION AND DIAGNOSIS

An inspector experiences the visual observation and the subsequent diagnosis as one action. This inspector directly interprets what he sees, without necessarily being aware of this. His diagnosis is generally based on years of experience. Such knowledge and skills is hard to unravel for outsiders.

For the analytical part, it is necessary to disconnect the diagnosis from the observation in order to make the diagnosis transparent and reproducible. Experiences made in the pilot studies of the PIW program have shown that this division increases insight and provides an opportunity for quality improvement of the inspections.

## SEPARATING OBSERVATION FROM PROGNOSIS/OPERATIONALIZATION?

The output of the diagnosis is used for the follow-up: drawing up the prognosis and the operationalization. Experiences made in the pilot studies have shown that a strict separation is enforced also for the analysis. For most damage, a diagnosis is made with the necessary follow-up actions in mind. Categorized divisions help to make the diagnosis efficient (what objective do you use to assess an observation?) and effective ('what is the desired type of follow-up action?').

## CLASSIFICATIONS

In order to address these concerns from actual practice, the Guide has made a distinction between two types of classification, namely in terms of quality, as used in the Digiguide, and in terms of urgency.

### *Quality categories from the Digiguide*

The Digiguide distinguishes four quality categories (see Table 3.2).

**TABLE 3.2 DIGIGUIDE QUALITY CATEGORIES**

Quality category	Description
good	The element fully meets the constructive and functional requirements
reasonable	The element sufficiently meets the constructive and functional requirements
fair	The element no longer sufficiently meets the constructive and functional requirements
poor	The element does not meet the constructive and functional requirements

*Urgency categories*

Damage situations can also be classified based on urgency of the follow-up actions, as depicted in Table 3.3.

**TABLE 3.3 URGENCY CLASSIFICATION OF DAMAGE**

<b>Urgency category</b>	<b>Description</b>
<b>Category 1: emergency repairs</b>	The deviation observed puts the flood defense system's strength/stability at immediate risk. Repairs have to be immediately made (within 1 - 2 days).
<b>Category 2: urgent repairs</b>	The deviation observed does not put the flood defense system's strength/stability at immediate danger. However, the deviation does have the potential to become worse in the short term which would jeopardize the stability of the flood defense system or which would result in significant repair costs. Repairs should be made urgently (within 1 - 2 months).
<b>Category 3: repairs before the closed season</b>	The deviation observed does not put the strength/stability of the water-retaining structure at immediate risk and does not have the potential to become worse in the short term. However, the deviation does put the flood defense system's stability at risk under normative conditions. Therefore, repairs have to be performed before the start of the closed season.
<b>Category 4: prognosis</b>	The deviation observed does not put the water-retaining structure's stability at immediate risk. It does not have the potential to become worse in the short term and the dike's strength/stability is not jeopardized under normative conditions. Repairs can be made in the long term. A further <i>prognosis</i> has to be drawn up.

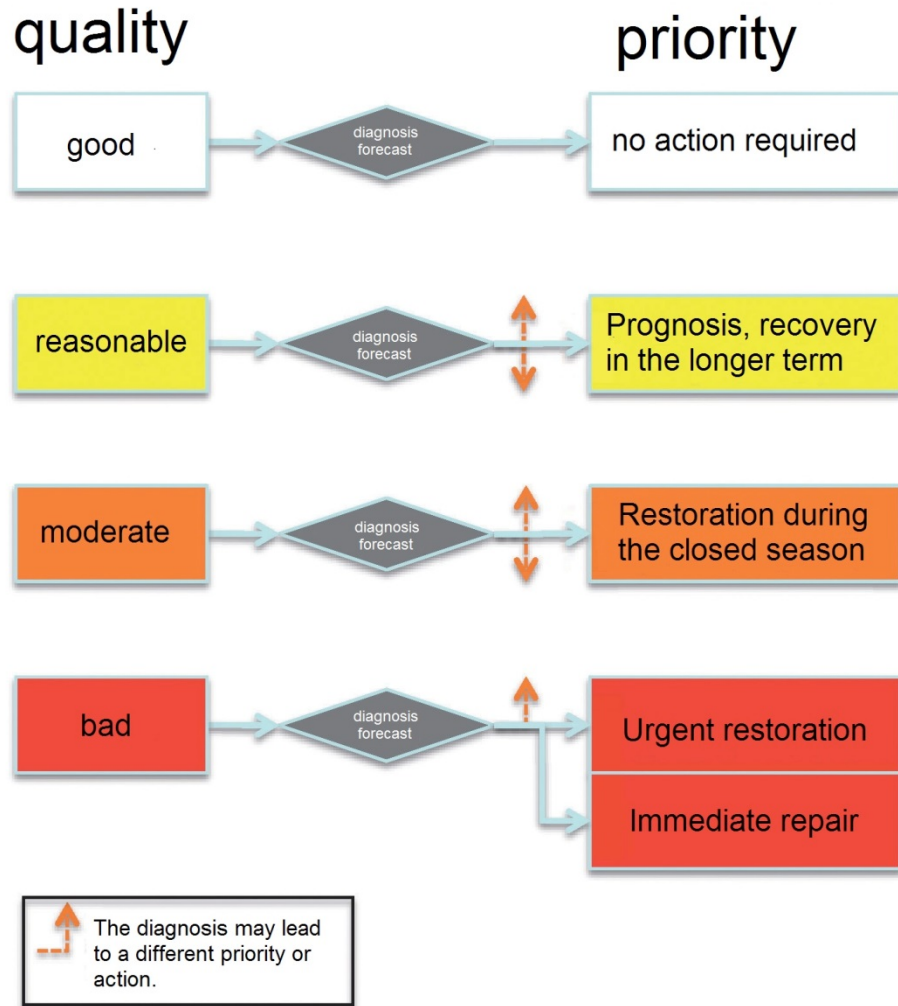
This classification divides within the damage scenarios the wheat from the chaff. Category 1 to 3 damages have a certain level of urgency and the repair term is clear. This is not clear in the case of category 4 damage. A further prognosis has to be drawn up for these damage situations.

*Relationship between quality and urgency classification*

Figure 3.2 shows the relationship between the quality and urgency categories. In connection with the structure of possible follow-up actions, it is preferred to keep these categories separate. Thus, the decision point with diagnosis and prognosis may point into different directions.



FIGURE 3.2 RELATIONSHIPS BETWEEN QUALITY AND URGENCY CATEGORIES



**NECESSARY DATA**

Sufficient data about the damage, the surroundings and the context has to be available for making a diagnosis. Table 3.4 shows the data (not exhaustive) that is necessary for making a good diagnosis.

**TABLE 3.4 DATA NECESSARY FOR DIAGNOSIS**

Component	Data
Geometry	Shape, crest height, settlements, subsidence, 'non-damming objects'
Embankment	Structure, type of soil, deeper sub-soil, non-damming objects (such as cables and pipelines), holes (moles, mice, beavers, foxes, rabbits, etc.)
Groundwater	Groundwater levels and rise levels, water content (peat dikes)
Grass cover	Root density, cracks, control forms (mowing, grazing, etc.), presence of unwanted plant species
Stone cover	Type of stone, crests, crown, wood cover, presence and quality of filter layer
Asphalt cover	Thickness, cracks, rigidity, emerging vegetation, stripping, holes
Load	<i>Normative conditions:</i> water levels, wave height, volume of overtopping and overflow, rates of flow, duration <i>Daily circumstances:</i> drought, traffic load, cattle
Surroundings	Nature of the protected area, type of open water, presence of shipping traffic, etc.
Testing	Are there relationships between deviations observed and results from the latest safety tests? For instance, is there a link between damage due to the failure mechanism that resulted in an insufficient score in the test?
Data from previous inspections	Has the deviation been observed for the first time or has the deviation been observed in previous inspections?

### DOCUMENTING RESULTS

For the sake of transparency and reproducibility, it is important that the results of the diagnosis have been documented and particularly the analyses been performed considering the background to the classification.

In addition, there is a clear link between the observed damage in the diagnosis and follow-up action (repair work/control measures or prognosis). In all cases, it is important that the documentation of the diagnosis makes it possible to receive a feedback from these follow-up actions, so that it may be assessed whether or not the desired result has been achieved.

### DIAGNOSTIC MODELS

The diagnosis mainly takes place based on knowledge and experience. Models are hardly ever used. Yet, models can be used in many ways. There are two types of diagnostic models.

The first group of models makes use of the data from general files with terrain data. With these models, a quick scan of the entire area of flood defense systems can be made. One example is the use of Flymap, based on which a first diagnosis can be made with the help of remote sensing observations.

The second group of models simulates the strength/stability of the flood defense system in great detail. They often make use of additional current data from measurements on site. These techniques are being developed in the IJdijk project.

#### *Digiprior*

Digiprior is a method for interpreting damage to flood defense systems in relation to the stability and prioritization of damage repairs. The approach starts from the idea that in the long term, over-strength can be determined from the data of the tests of flood defense systems. The proposed method may be particularly useful for regional flood defense systems of sufficient importance. The damage is entered and documented with the help of Digispectie ('Diginspection').

The interpretation of damage in Digiprior is a two-fold process: the qualification of the damage situation by observation of field inspectors (score  $S_i$ ) and the relationship of the damage observed to the possible failure mechanism (score  $T_i$ ). Score  $T_i$  is linked to the over-strength of the flood defense system for the failure mechanism on which the damage may have influence.

### 3.3 PROGNOSIS

#### OBJECTIVE

The prognosis is aimed at determining the development of the Category 4 damage situation across a certain period of time (see also Table 3.3).

#### WORKING METHOD

In prognosis, the cause of the damage situation and the manner and speed of developments are determined across time. In the case of height measurements, the diagnosis may be that the height of the flood defense system has been reduced as a result of settling. In the prognosis, the expected further decrease of the height is estimated for the long term.

#### RESULTS

The result of the prognosis is an overview of measures for the projected Category 4 damage situations. These measures vary from maintenance and repairs (in the long term, or not) to monitoring the developments over time.

### 3.4 OPERATIONALIZATION

#### OBJECTIVES

- Defining and prioritizing the necessary actions which solve the detected damage/deviation;
- Inspection of repairs made;
- Adjusting the inspection, for instance, more intensive inspection of flood defense systems with many or frequent damages, a more extensive inspection of flood defense systems with over-strength.

#### WORKING METHOD

The required measures are defined, prioritized and included in the inspection report (Chapter 5). In cases that the department responsible for the inspection is also responsible for the observed damages, the resources and planning necessary for the remedial actions may also be included in the report. However, there are also organizations in which the inspections and execution of inspections are handled separately. Since these are two separate processes, the relationship with the execution of the required measures is not described in more detail.

The work performed must be inspected, documented and reported back. Based on these findings, it is (implicitly) assessed whether or not the work carried out has brought the condition of the flood defense system to within the safety standards.

## RESULT

The result of the operationalization is the inspection report in which are included: the results of the inspections, an overview of the damages observed, the necessary actions and their prioritization with special attention to the inspection results of recently executed remedial actions.

### 3.5 FOUR VERSIONS IN SPECIFYING DIAGNOSIS AND PROGNOSIS

There are several organizational models on how the inspection can be structured according to the four subprocesses. The Guide discerns four alternative structures (see Figures 3.3 - 3.6). Each alternative sets its own requirements to the training level of the field inspector and office staff.

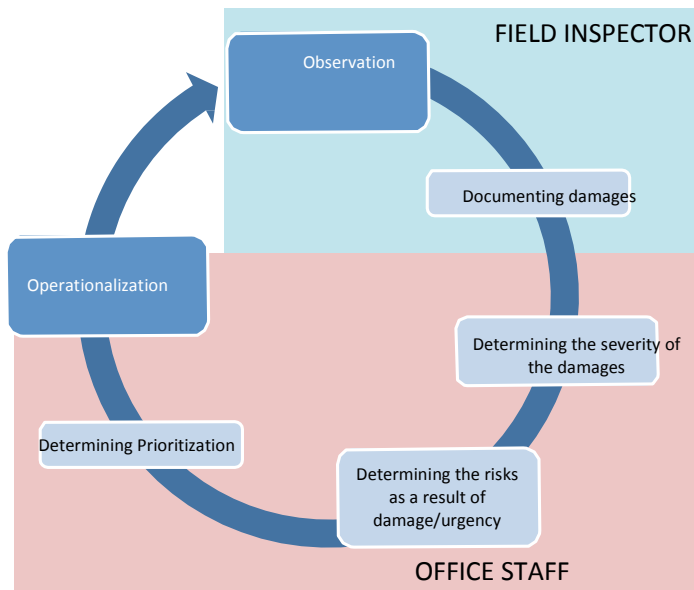
#### VERSION 1: DIAGNOSIS AT THE OFFICE

The inspector makes the observation and the office staff interprets the observations based on his own knowledge of failure mechanisms. This division of tasks is intended to allow the inspector to detect, recognize and interpret quality.

The characteristics of this version are:

- The educational level of the inspectors is at the intermediate vocational level, including the courses Dike Inspector I and II/Visual Inspection;
- Attention to uniform observation (many staff members in the field, regardless of diagnosis);
- Uniform diagnosis: all damage situations are drafted by one/single staff member.

FIGURE 3.3 DIAGNOSIS AT THE OFFICE



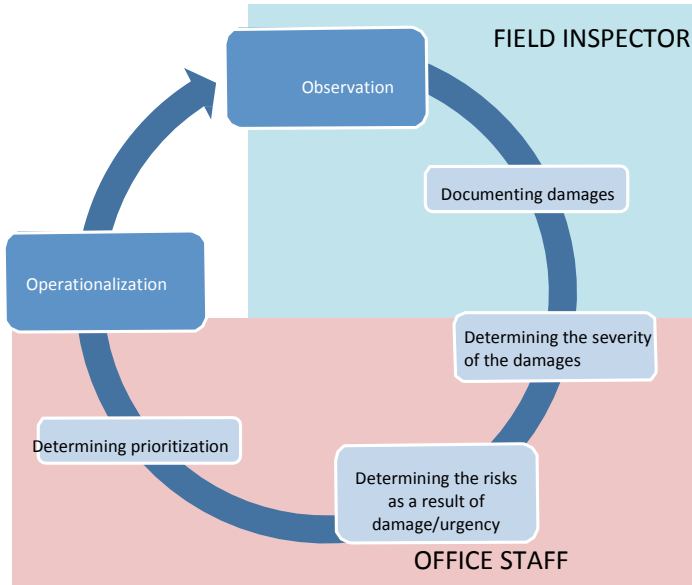
#### VERSION 2: DIAGNOSIS IN THE FIELD AND AT THE OFFICE

This version is characterized by a certain overlap between the diagnosis made by the field inspector and that made by the office staff. Both have knowledge of the failure mechanisms of the flood defense system. The inspector first draws up a diagnosis of the observations. In cases of doubt, the office staff is being consulted to make the final diagnosis. In the case of such a task division, the inspector must be able to make a reliable first diagnosis.

The characteristics of this version are:

- The inspector has an university degree in applied sciences with specialization in hydraulic engineering and flood defense systems;
- Diffuse division between which part of the diagnosis is made by the inspector and which part is made by the office staff.

FIGURE 3.4 DIAGNOSIS IN THE FIELD AND AT THE OFFICE



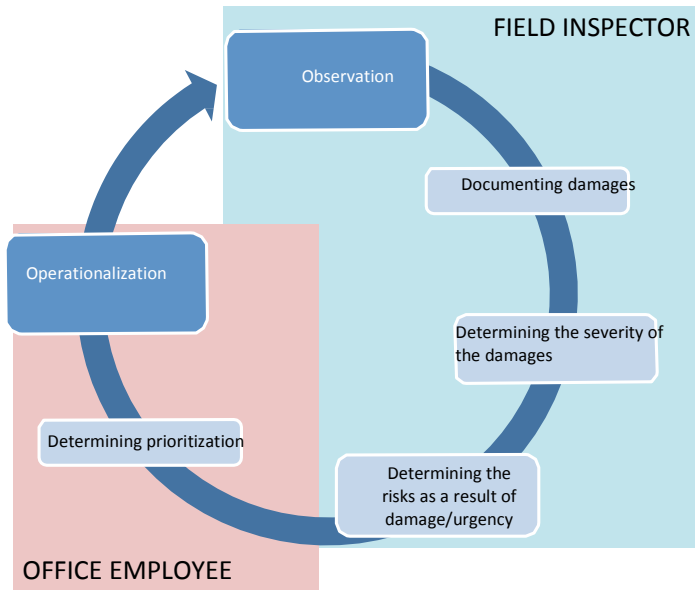
### VERSION 3: DIAGNOSIS IN THE FIELD

In this version, the inspector performs both the observation and the diagnosis himself; the office staff focuses on the follow-up actions. The inspector possesses the required knowledge of failure mechanisms in order to make the right diagnosis. In this task division, the inspector must also be able to make a good prognosis.

The characteristics of this version are:

- The inspector has a university degree in applied sciences + a level of knowledge of failure and collapse mechanisms, ageing processes, and risk analysis;
- Chances of the occurrence of 'isolated islands', insufficient data management (can be countered by peer review).

FIGURE 3.5 DIAGNOSIS IN THE FIELD



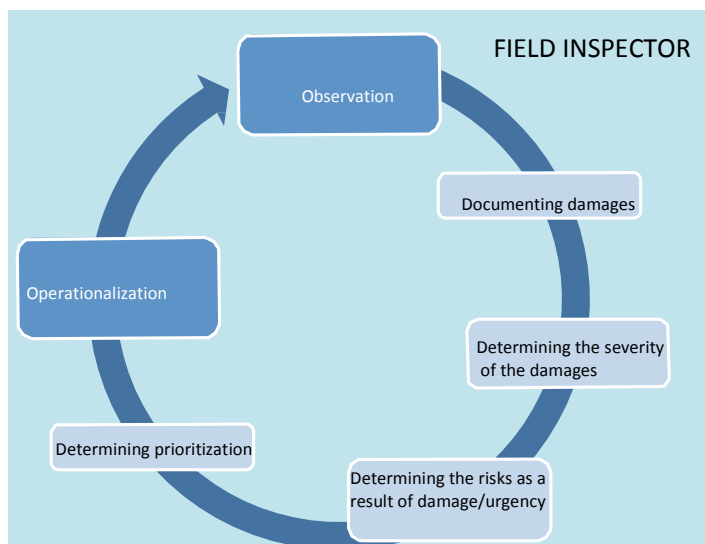
**VERSION 4 CONTROL FULLY IN THE HANDS OF THE INSPECTOR**

In this version, the inspector is responsible for the entire inspection process and therefore also has knowledge of - planning and budgeting - the execution.

The characteristics of this version are:

- The inspector has full knowledge sufficient for making observations and diagnoses (university degree in applied sciences + knowledge about failure and collapse mechanisms, ageing processes and risk analyses, maintenance work, the contents of long-term maintenance programs, historical maintenance data);
- Increased chances of occurrence of 'isolated islands', possibly less data management than in version 3 (all actions are in the hands of the same staff member).

FIGURE 3.6 CONTROL FULLY IN THE HANDS OF THE INSPECTOR



# 4

## THE INSPECTION PLAN AS A DRIVER FOR IMPROVEMENT

The inspection plan:

- provides an overview of the correlated activities for the structuring, performance and position of inspections, detailed according to the various flood defense systems under management;
- ensures a professional performance of the inspections while meeting a number of quality standards;
- is an integral plan that provides clarity about the implementation and positioning of the inspection process across several departments and staffs.

The inspection plan makes the inspection process visible, documents it structurally and forms the basis for quality improvement. Drafting an inspection plan acts as a catalyst for improving inspections: since both, clients and inspectors are interviewed, they gain more insight in the inspection process, the necessity of and options for improvement.

This chapter discusses the possible structures with which the plan can be structured. It deals with the organization-specific focal points and discusses the drafting of the inspection plan. Finally, special attention is given to quality standards, linking inspections to management systems and the training of personnel.

### 4.1 THE INSPECTION PLAN DESCRIBES THE ENTIRE INSPECTION PROCESS

An inspection plan consists of a complete description of the inspection process. In principle, there are three possible divisions of the inspection plan:

- The *inspection process* is at the center. This leads to separate sections for the subprocesses observation, diagnosis, prognosis, operationalization, within which the activities are described per type of flood defense system;
- The *category of flood defense system* is at the center, which results in separate sections or parts for primary flood defense systems and regional flood defense systems, with each a description of the four subprocesses observation, diagnosis, prognosis and operationalization;
- The *type of inspection* is at the center, which leads to a section for spring inspection, a section for daily inspections, etc.

The choice for division depends on the area, the structure of the management organization and the inspection method. It may happen that the inspections of primary and regional flood defense systems are executed by various departments, completely separate from the execution, or not. It may also happen that the outsourcing is handled differently per each type of inspection.

Experience taught that the first two divisions are the most common ones.

## 4.2 THE INSPECTION PLAN IS ORGANIZATION-SPECIFIC

Essential to the structure of the inspection process is that the progress is monitored. It must be clear in advance who monitors the progress and where the responsibilities are.

Focus here is that the structuring of inspections is organized differently in each organization (see also chapter 3.4).

### CHECKLIST FOR COMPLETING THE INSPECTION PLAN

Below are a few points in attention to completing the four subprocesses:

- General:
  - Inspection objectives (e.g., only the technical state of the flood defense systems or in combination with enforcement);
  - Type of inspection (see chapter 2.1.);
  - Clients (see chapter 2.2.);
  - Education and training of the inspectors;
- Before the inspection:
  - Equipment of the inspector;
  - License for entering the flood defense system + announcements in the media;
  - Instruction for use of equipment (e.g., use of tablet PCs);
  - Type of and requirements for reporting;
  - Duration of the inspection;
- During the inspection:
  - Accessible support at the office for inspectors with questions in the field (all types of questions from using the tablet PC to questions about enforcement and questions of landholders);
- After the inspection:
  - Feedback of the results to the inspectors;
  - Report to the defined clients: management, other departments, board, supervision;
  - External communication.

Table 4.1 shows that each subprocess generates information that must be transferred to the following subprocess. In its execution, it can be seen that the tasks in an inspection are mostly divided among multiple staff members. Therefore, it is important that the transfer of information is well organized and that is has been documented.



**TABLE 4.1 NECESSARY PROCEDURES AND INSTRUCTIONS PER SUBPROCESS**

Procedures and instructions	Observation	Diagnosis	Prognosis	Operationalization
Standardized working method	X	X	X	X
Instruction working method documentation data and information	X	X	X	X
Procedure transfer of information to the next organizational part	X	X	X	X
Procedure monitoring accurateness and completeness of data	X			
Procedure monitoring of progress and completion of actions	X			X
Procedure actions link to operational management				X

In operationalizing the inspection results, initiated follow-up actions have to be monitored up to handling and completion. Clear agreements are required about the conclusion of the inspection cycle and the documentation of the results. Documentation and accountability of the results may be laid down in reports (see also chapter 5).

### 4.3 DRAFTING AN INSPECTION PLAN

Table 4.2 shows the phases that need to be followed in drafting an inspection plan.

**TABLE 4.2 THE PHASES INVOLVED IN DRAFTING AN INSPECTION PLAN (SEE ALSO ANNEX D)**

Phase	Work
<b>O. Preparation</b>	<ul style="list-style-type: none"> <li>Write a project proposal 'drafting an inspection plan'. Describe the assignment, approach, project organization, project execution, project planning, decision moments and required budget.</li> <li>Have the project proposal determined. This may seem an obvious step, but experience in the pilots has shown that it is little use to work at an inspection plan if the initiative is not supported by the organization.</li> </ul>
<b>A. Determine the baseline situation</b>	<ul style="list-style-type: none"> <li>Map out the area to be inspected.</li> <li>Document the current practice of inspections (see also Annex E).</li> </ul> <p>Please note: the description of the baseline situation provides valuable input for the discussion about objectives and means for inspections.</p>
<b>B. Determine the desired situation</b>	<ul style="list-style-type: none"> <li>Map out relevant policy and objectives chosen and determine the role of inspections in this.</li> <li>Determine the types of inspection: objective, frequency, period, aspects to be observed, manner of documentation.</li> <li>Determine the desired situations (technical and outward appearance) of the desired state of maintenance per category of flood defense system.</li> </ul>
<b>C. Draft the improvement plan</b>	<ul style="list-style-type: none"> <li>Map out what (organizational) changes have to be implemented to reach the desired situation.</li> <li>Determine the expectations regarding the performance to be delivered.</li> <li>Determine the required deployment, planning and budgets.</li> </ul>

### 4.4 QUALITY

There are no quality standards for inspecting flood defense systems. Quality standards for other forms of inspection are not or only limitedly applied. Therefore, this section is limited to a general description.

The quality of the inspections and the results depend primarily on quality assurance of the four subprocesses and of the information transfer between the subprocesses. Additionally, quality depends on other business processes of the flood defense system control, such as license issuing, enforcement, execution (maintenance and improvements) and information management.

Reproducibility of results is an important indicator. Therefore, it is important for the subprocesses of inspections and for the supporting processes to strive for:

- Uniform and standardized working methods;
- Minimum requirements for education and experience;
- Connection to organization-generic standards, such as ISO certification, KAM certification and UPP.

Annexes F and G provide more information about the details of high-quality inspections.

The inspection plan is the concrete means for planning, management and evaluation. The most important instrument for the evaluation is the report, which is discussed in chapter 6.

#### **4.5 INSPECTIONS AND THE CONTROL SYSTEM**

For a good inspection, it is not only important that the organization of inspections is structured and set up well, but also that the flow of data is well organized. To this end, it is necessary to have a clear picture of:

- Who is responsible for a certain part in the technical implementation of inspections;
- Who performs what type of action regarding data and equipment;
- What type of data must be ready beforehand;
- Where and how inspection data is stored.

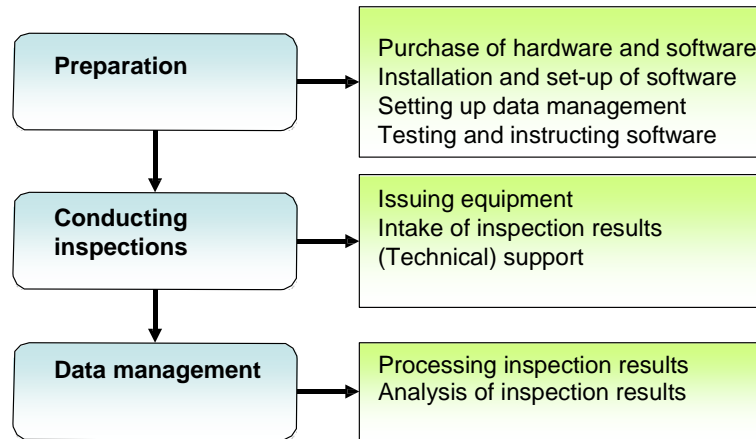
This section deals with the points above. In view of the fact that each control organization is organized differently, no ready-made standard inspection plan can be laid down here. The information is mostly intended as a checklist for (future) parties involved.

In describing the control systems, this text starts from the idea that the use of Diginspection software for the field inspections and the IRIS module for data management. In practice, other software may be used. It does not make a difference in the description of the process steps in theory.

#### **ORGANIZATION OF INSPECTION CONTROL SYSTEMS**

Figure 4.1 describes the most important system-technical process steps, which apply to the (digital) documentation and management of inspection results.

FIGURE 4.1 DOCUMENTING AND CONTROLLING INSPECTION RESULTS



Various specialists within the organizations are involved in the different steps:

- 1 *Preparation*: data managers, application managers, ICT specialists;
- 2 *Execution*: flood defense system controlling authorities, inspectors, application managers;
- 3 *Data management*: flood defense system controlling authorities, application managers, data managers.

These steps are explained below.

### STEP 1: PREPARATION

#### *Choice in equipment*

Equipment is needed for the digital inspection. It supports, facilitates and preferably increases the quality of the inspectors' work. Every month, new hardware models are marketed. Therefore, it is not possible to provide advice about the best type of hardware to be used.

#### *Installation and set-up of software*

Software has to be installed on the equipment. Documenting damage situations usually takes place based on the GPS location in combination with reference points of topographic bases (Top10, GBKN, dike poles, etc.). These GIS files also have to be installed on the equipment. Compatibility between hardware, software and data files (GIS files) requires attention.

#### *Setting up data management*

The desktop environment must be set up with software and locations where data files (inspection results, photographs) should be placed. It is possible to save inspection results in IRIS, so that they become available for any interested party within the organization. It is necessary for the storage and processing of photographs of damage situations to determine a data structure beforehand, as a result of which the photographs can be made available in the longer term.

#### *Testing and instruction*

Before an inspection can be conducted with the equipment and software, it is necessary to thoroughly pretest everything under conditions equal to inspection. Good training for inspectors in the use of hardware and software prevents potential disappointment during the inspection itself.

## STEP 2: CONDUCTING INSPECTIONS

### *Data processing*

A huge amount of data is collected during the inspections. The data has to be stored and processed in between. This prevents data loss and it enables an interim quality control of the inspections or the way of documentation. Damage situations that require a direct control measure will also be revealed during data processing.

### *Office helpdesk*

Inspectors may have questions about the inspection and assessment of damage situations during inspections, but also about the technical functions of hardware and software. Therefore, an expert should be available to answer the questions of the inspectors.

## STEP 3: DATA MANAGEMENT

In this phase, photographs can be processed by linking them to the inspection points and by sending those to the Digiguide (see also chapter 3.1). In this phase, the assessment of the inspection results may also take place. Maps and tables can also be created, which originate from the management application and which can be added to the report to be drafted.

## 4.6 TRAINING

Staff who is involved in the inspection of flood defense systems in different roles, must be adequately trained, as has been explained in chapter 3.4. Table 4.3 shows the details of training requirements per task. The training levels are indicative only, in view of the fact that no account is taken of experience and specific knowledge of the inspector concerned.

**TABLE 4.3 OVERVIEW OF TRAINING AND EXPERIENCE LEVEL PER TASK/ROLE IN THE INSPECTION PROCESS**

Task	Guideline for educational requirements
Observation	Civil Engineering degree at an intermediate vocational level. Courses: Dike Inspector 1 and 2, Visual Inspections.
Diagnosis	Civil Engineering degree at a university level in applied sciences. Additional training in hydraulic engineering and flood defense systems. Is able to hire and manage specialists (e.g., soil mechanics). Knowledge of inspection techniques.
Prognosis	Civil Engineering degree at a university level in applied sciences. Knowledge of failure and collapsing mechanisms. Knowledge of ageing processes and risk analyses.
Operationalization	Knowledge of: maintenance work. The contents of the current long-term maintenance programs. Historical maintenance data.

The Stichting Wateropleidingen ('Foundation for Water Education') offers many trainings in the area of water safety with, among other things, courses in 'Visual inspection of flood defense systems', 'Basic knowledge of flood defense systems', 'Risk analysis in the water sector', 'Security of regional flood defense systems' and 'License issuing under the water board by-law' (with special attention for the flood defense systems). These courses are taught by specialists of the flood defense system controlling authorities, which realizes a good connection to actual practice.

The course 'Visual inspections of flood defense systems' is obviously the one that is most specialized in dealing with:

- The desired inspection process;
- Failure and collapse mechanisms;
- Visual inspection of damage situations of river, sea and regional flood defense systems;
- Use of Digiguide;
- Structured documentation;
- Analyses of observations;
- Use of Diginspection.

# 5

## REPORTS

Reports are the information carriers of the results of the inspection process. The Guide details the three most common types of reports. Finally, it discusses the communication about the inspection reports and the monitoring of the follow-up actions as a result of the findings in the reports.

### 5.1 THE 'HOW' AND 'WHY' OF REPORTS

#### WHY REPORTS?

Inspections of flood defense systems are one part of the regular activities of a flood defense system controlling authority. The associated reports should therefore be a standard component of the reports concerning the control of flood defense systems and should dovetail with the other reports (annual reports, periodic management and control reports and memoranda for budgets and policy plans). They provide insight to the extent to which the controlling authority 'is in control' and they are a part of the responsibility of the landholders and responsible government bodies.

#### OBJECTIVE

Drawing up reports about completed inspections is intended to inform the departments, management, board and supervisory boards about the results of the inspections carried out (maintenance and security situation of the flood defense systems), the follow-up actions (including the prioritization and any planning and costs) and the proposals for improvement for the next inspection. The main goal of drafting clear and accessible reports is to inform the target groups as adequately as possible.

#### TYPES OF REPORT

The inspection reports are generally drawn up at the three levels: control, management, and board. Table 5.1 provides further information about these types of report.

- 3 With the Water Administrative Agreement, the information provision on the part of the flood defense system controlling authorities has been made dependent on the type of flood defense system. The inspection reports are thus provided to either the central government (primary flood defense systems) or the provinces (regional flood defense systems). It is not clear yet which requirements are set to these reports. These differ per province for the inspection results of the regional flood defense systems; no requirements are yet identified for the primary flood defense systems.

**TABLE 5.1**      **TYPES OF INSPECTION REPORT**

<b>Report</b>	<b>Target group</b>	<b>Objective</b>	<b>Frequency</b>	<b>Detail</b>
<b>Control report</b>	Departments directly involved in inspections/control and maintenance	Quality of the flood defense system and necessary actions	-	High
<b>Management report</b>	Person ultimately responsible for the inspection process:	Quality of the flood defense system and of the inspection process plus necessary actions for improvement	-	Medium
<b>Administrative report</b>	Board and supervisory bodies	Quality of the flood defense systems	Annually	Low

The level of detail in the report decreases in the chain of reports – from control report to management report to administrative report. Control reports are the most detailed and form the basis of the other reports. Management and administrative reports mainly contain abstract and aggregated information, as at these levels people steer towards objectives, making budgets available and creating sound conditions and circumstances in the organization. Naturally, all reports should be based on the same data.

In addition to the inspection results and the necessary ensuing measures, management and/or board can be informed about the proceedings and learning experiences. In that case, proposals for improvement are a part of the reporting process.

### **FREQUENCY OF REPORTS**

Board and management usually receive a report at least once a year. In the event of special circumstances and calamities (high water, storm, drought), more frequent reports are required. This belongs to the duties of the crisis management coordinator and is not included in this Guide.

## **5.2 THE THREE TYPES OF REPORTS FOR THE MOST COMMON TARGET GROUPS**

### **CONTROL REPORT**

The control reports should always be complete and detailed. It forms the basis for the management and administrative reports and offers insight into the operational objectives. In addition to the inspection results, the report should also provide insight into which components of the inspections can be further improved.

Table 5.2 shows the possible structure of a control report with the associated (minimum) contents.

**TABLE 5.2 THE COMPONENTS OF A CONTROL REPORT**

Subject	Component	Information
Security level	Map	Location and category of flood defense systems; Inspection results (per category <sup>4</sup> ): Category 1 to 3: <b>red</b> ; Category 4: <b>orange</b> ; Good: <b>green</b> ; Planned, not inspected: <b>grey</b>
	Table	Further details to category 1 to 4: Grouped according to damage, zone (inner slope, crown, outer slope) and/or causes; Summed up according to length/surface area
	Photographs	Illustrative
Improvement	Overview	List of necessary actions per type of damage and locations
	Planning	Estimation of means and time per type of damage; Overview of who is responsible for which actions.
Quality	Inspection plan	Applicability (extent to which the inspections have been performed in accordance with the inspection plan); Planning versus realization of inspection in time and money.
	Process-related deviations	Motivation for not-performed inspections (for instance, insufficient manpower, insufficient budget, insufficient prioritization, ...); Motivation of other deviations from the inspection plan.
Improvement of inspection process		Overview of any actions for improvement (training of inspectors, purchase of equipment, ...).

### MANAGEMENT REPORT

The management report should be:

- short and concise;
- give a picture of the current situation of the flood defense systems belonging to the controlling authority;
- give a picture of the administrative influence - as required and possible - on the results (or proposals) with the associated risks.

Table 5.3 shows the possible structure of a management report with suggestions for content.

4 See Table 3.2 for an explanation of the categorization.



TABLE 5.3 THE COMPONENTS OF A MANAGEMENT REPORT

Subject	Component	Information
Security level	Map	Location and category of flood defense systems; Inspection results (per category <sup>4</sup> ): Category 1 to 3: red; Category 4: orange; Good: green; Planned, not inspected: grey
	Table	Further details to category 1 to 4: An overview of the detected damages.
	Photographs	Illustrative
Remedying shortcomings	Overview	Summary of necessary actions per type of damage. Division into work executed and enforcement actions
	Planning	Estimation of means and time per type of damage; Overview of who is responsible for which actions.
	Analysis of damage situations	Analysis/Explanation of prevalent damage situations; Overview of proposal/ necessary preventative measures.
Quality of inspections		Estimation of quality of inspection results; Inspectors trained/qualified, instructions and evaluation of inspectors, processing results.
Improvement of inspection process		Overview of any actions for improvement (training of inspectors, purchase of equipment, ...)

### ADMINISTRATIVE REPORT AND REPORT TO THE SUPERVISORY BODIES

Administrative reports are freely accessible documents. This means that they are also documents with which the controlling can be held accountable by the wider public. The reports should be in line with this objective (see Table 5.4). The reports for the board - almost in their entirety- can be used for the supervisory bodies i.e., Province or central government, as well. Sometimes, the supervisory body concerned may set additional requirements to the reports.

<sup>5</sup> See Table 3.2 for an explanation of the categorization.

TABLE 5.4 THE COMPONENTS OF AN ADMINISTRATIVE REPORT

Subject	Component	Information
Security level	Map	Location and category of flood defense systems; Inspection results (per category <sup>6</sup> ): Category 1 to 3: red; Category 4: orange; Good: green; Planned, not inspected: grey
	Table	An overview of the total km of flood defense system, with a summary per category of flood defense system across which length the flood defense systems are damaged.
	Photographs	Illustrative, if applicable.
Remedying shortcomings	Table	Actions that need to be taken to restore the security level on routes with insufficient scores; Which measures will require an administrative decision; When measures should be completed; Which investments will be necessary.
Review		Discussion of improvements executed in the previous year.
Professionalism of the organization		The extent to which the inspection is in accordance with provincial by-laws and/or national standards/laws The extent to which the controlling authority agrees - administratively - with the working methods applied; How the inspection related to those in place at other flood defense system controlling authorities.

### 5.3 COMMUNICATION

In consultation with the communication and information professionals, the administrative report may form the basis for communication about the inspection results via the website, a newsletter and other means of communication used by the controlling authority.

Communication about the inspection itself must also be included. What is and how it is communicated, depends to a great extent on the ownership situation of the flood defense systems controlled by an authority. If a controlling authority owns all flood defense systems and surrounding ground, a more extensive communication is required. This is different if the flood defense system runs through several back gardens, for instance. Annoyance and misunderstanding can be prevented by communicating clearly and in a timely manner about the inspection planning and inspection actions.

### 5.4 THE FOLLOW-UP ACTIONS MUST ALSO BE INSPECTED

Naturally, any follow-up actions (repair/management) formulated as a result of the inspections must also be carried out properly and correctly. The manager of Control and Maintenance/Performance is responsible for this. The department that is responsible for inspecting flood defense systems may play a role in the execution and/or delivery of the work. Clear agreements have to be made about this. Depending on the scope of the follow-up actions and the planning, it may be opted to have the delivery inspection of the repair work coincide with the regular inspections.

<sup>6</sup> See Table 3.2 for an explanation of the categorization.

# 6

## ASPECTS RELATED TO INSPECTIONS

### 6.1 SAFETY TESTS

#### PRIMARY FLOOD DEFENSE SYSTEMS

In accordance with the Water Act, the primary flood defense systems must be tested once every six years. However, in the Water Administrative Agreement of May 2011, it has been laid down that the frequency must be decreased to once every twelve years. The fourth test will start in 2017. It was also agreed to divide policy and implementation as strictly as possible according to the 'two-layer model'. This means that the central government as the controlling authority of the primary flood defense systems lays down the standards and supervises the manner of testing and that the flood defense system controlling authorities (Regional Services of the Directorate-General for Public Works and Water Management) perform the tests and directly report to the central government.

A substantial amount of technical information is needed for these safety tests. This information can be partially retrieved during the inspections of the flood defense systems, and may be used for both the technical test, in accordance with the VTV, and for drafting the control assessments. Experienced acquired with the inspection may result in issuing a deviating control assessment and may be used to substantiate these.

#### REGIONAL FLOOD DEFENSE SYSTEMS

From the role of controlling authority of the regional flood defense systems, the province designates them and provides standards for them<sup>7</sup>. The manner and frequency of testing of the regional flood defense systems has been laid down in provincial by-laws. The flood defense controlling authorities test their regional flood defense systems and submit the results to the province(s).

*Example of Wetterskip Fryslân:* Due to large area of flood defense systems (3,400 km) the controlling authority and the Province of Friesland has chosen to make a distinction at a difference in water level of 1.5 m;

- Regional flood defense systems with a greater differentiation are tested according to the STOWA Guideline for Safety Tests.
- The other flood defense systems are tested for their minimum robust profile with the help of a geometric test. The flood defense systems with an insufficiently robust profile are also tested with the help of the STOWA Guideline for Safety Tests.

The tests of the other flood defense systems, which thus have a sufficiently robust profile and a maximum water level difference of 1.5m, which is the majority, consist of the results of the annual inspection in combination with the five-annual height measurements.

<sup>7</sup> The Directorate-General for Public Works and Water Management sets the standards for the regional flood defense systems in its control.

The options of using the inspection for testing the regional flood defense systems are relatively great, particularly for basin quays. This is because the standard situation closely resembles the daily situations, particularly compared to that of the primary flood defense systems. This means that the inspection results of the daily situation give a good indication of the strength and behavior of the flood defense system under normative conditions.

### **CONTROL ASSESSMENT**

A part of the information required for these tests may be derived from the inspections, such as the substantiation of the control assessment and the drafting of plans for improvement, which may entail making use of the long-term series of inspection results.

### **THE KNOWLEDGE OF THE INSPECTOR IS INDISPENSABLE TO THE TESTER**

The Safety Test Regulations of the primary flood defense systems and the Guideline for Safety Tests of the regional flood defense systems have a strong (geo)technical approach, so that statements can be made about the qualities of the flood defense systems under normative conditions. These normative conditions are simulated as well as possible through extrapolations of measurement data. However, there is little (regional flood defense systems) to no (primary flood defense systems) experience with the normative conditions. This has led to the fact that inspection results cannot be used one-on-one in tests.

On the other hand, the actual experience in the field, both regarding daily conditions and extreme conditions, provide valuable information about the qualities of the flood defense systems. However, it has not been worked out yet whether and if so this information can be included in the safety tests.

This does not alter the fact that a good exchange of information is needed between the tester and the inspector. Both may benefit a lot from each other's knowledge and experience. This seems obvious, but is in fact not self-evident, particularly not in such situations where testing and/or inspections are being outsourced.

### **THE KNOWLEDGE OF THE TESTER IS INDISPENSABLE TO THE DIAGNOSIS**

In safety tests, the flood defense systems are assessed and evaluated. This knowledge may be useful for inspections, particularly in the subprocess of diagnosis. A structural involvement in the execution of the diagnosis by testers is therefore preferred. A specific deployment in the event of complex situations is also conceivable.

## **6.2 OUTSOURCING INSPECTIONS**

### **DETERMINE WHAT TO OUTSOURCE AND WHAT YOU DO INHOUSE**

A controlling authority is regularly faced with the choice of determining what type of activities can be performed by its own staff and what can be outsourced. The underlying reason for this choice is largely a financial and/or administrative one: is the supervision of the flood defense system being efficiently executed and is the market sufficiently involved in the work of the central government? For the Directorate-General for Public Works and Water Management, these questions form the background to the 'market, unless' approach. This issue also regularly comes up with the water boards.

The key to outsourcing the inspections of flood defense systems is the manner in which the controlling body can guarantee responsibility:

- If its own staff is being used, the advantage is that they need less supervision;
- If work is outsourced, the question of how to 'inspect the inspector' comes up, and if this is really necessary.

There is no clear-cut answer to this. For instance, the benefit of having the inspection performed by own staff can be countered by the fact that 'alien eyes on the dike' may result in a new approach to certain issues.

In the case of outsourcing, quality assurance is an issue. As has been stated before, there are no quality standards available for the inspection of flood defense systems (see Chapter 3.4). There are, however, general recommendations:

- Work according to the inspection plan. An alternative approach in outsourcing is that project bidders can be required to draft (proposals for) inspection plans.
- Separate the outsourcing of inspections from other control duties;
- Require risk analysis to be performed by the project bidder with the subject-related high risks being mapped out. The contracting authority determines the contract form and the bidder profile in part based on these high risks. Only an inventory of demand-related risks is made; solution-specific risks are not yet viewed in this phase.

## **PROCUREMENT STRATEGY**

The following considerations are relevant in procurement:

- Awarding based on lowest price or economically most advantageous tender. The choice partially depends on the level and scope (complexity) of the inspections to be outsourced and takes place based on risks and knowledge and experience levels of the bidders;
- The selection requirements i.e., the suitability criteria and grounds for exclusion, must be attuned to the bidder's profile;
- Be wary of too much bureaucracy in the bidding process;
- Strive for open communication between contracting authorities and bidders. Coordinate expectations.
- Pay attention to transparency regarding division of risks carried between the contracting authority and the bidder, as well as the manner in which contingencies must be handled.

## **OUTSOURCING**

The following considerations are relevant for outsourcing:

- Form (draw up standard contract models);
- Contract form. Rating based on the nature of the project, the desires of the contracting authority (project objectives) and the knowledge and experience level of the market;
- Contract management;
- Manner of communication between the contracting authority and the bidder. A good cooperation and communication between the contract parties are absolute conditions in order to achieve a successful risk allocation or risk management;
- Risks:
  - Be concise about each party's responsibilities. Explain those duties and responsibilities (particularly in the public domain) that can be performed more effectively by the bidder than by the contracting authority;
  - Document how risks should be handled and strive for a balanced division;
- Prevent paperwork (contracts) from becoming too large;

- Try keeping control of the (transaction) costs;
- Keep a close eye on selection criteria and make a selection based on quality and not only on costs.

### 6.3 THE IMPORTANCE OF INSPECTIONS FROM A LEGAL PERSPECTIVE<sup>8</sup>

In addition to standards, inspections play an important role from a legal perspective both in 'regular' control and maintenance and in crisis situations. Ever since the legal ruling in the Wilnis case, this has received greater attention. Therefore, this has been included in this Guide.

#### FAILURE OF THE PEAT DIKE IN WILNIS: TIGHTENING OF LIABILITY

As a result of the damage compensation proceedings after the breach of the peat dike in Wilnis (August 2003), stipulates that peat dikes, and therefore also regular dikes, are legally classified as buildings. This creates a risk-based liability with the owner of the peat dike. This risk-based liability is in place in addition to the liability of the controlling authority that is in charge of a dike.

Risk-based liability is very different from fault-based liability of the controlling authority. Liability based on fault for failure to fulfill duty to care on the part of the controlling authority is considered best efforts obligation: if the controlling authority can demonstrate that it has properly performed his (control) duties, which means according to prevailing opinion, it cannot be held liable for unforeseen crisis situations.

Now that flood defense systems are viewed as buildings, the scope of liability has greatly increased. In addition to the controlling authority, which may or may not be the owner/proprietor of the dike, other owners of the flood defense system may also be held liable. One example is the situation in Kampen, where individuals are the proprietors of a part of the flood defense system.

Who can be held liable for damage arising from a faulty dike?

In general, when things go awry in control and maintenance or in other situations, the following individual can be held liable for any damages:

- *The flood defense system controlling authority (liability based on fault).* The controlling authority may be held liable if:
  - *Failure* to perform its duties properly. Something went wrong, or the controlling authority did something wrong;
  - *Proper* performance of duties, for instance when flood defense systems are constructed or strengthened. This legitimate performance of duties on the part of the controlling authority may result in certain individuals incurring disproportionate damage in comparison to others. In such cases, there is reason to pay *compensation for loss resulting from administrative acts*;
- The owner (liability for structural defects):
  - The *flood defense system controlling authority* that possesses (or owns) a flood defense system may be held liable for damage incurred due to a faulty dike. Even if the controlling authority did nothing wrong or failed in doing something; the culpability is, in principle, not relevant. Therefore, the controlling authority that is also the owner of a flood defense system runs twice as much risk of paying for damages, but obviously does not have to pay damages twice to the same person;

<sup>8</sup> Based on the presentation of Professor H.F.M.W. van Rijswijk on the Knowledge Day Flood Defense Systems Inspections 2011.

- A non-controlling authority may also partially own a flood defense system, for instance a climate dike. If something goes wrong, each part-owner is, in principle, liable for the entire damage ensuing from a faulty dike.

### **What can the flood defense system controlling authority be held liable for?**

The controlling authority can be held liable in the following situations:

- 1 *Acting*. This concerns inspections, for instance, in which it is assessed if the requirements are still being met, weak spots are detected and for which measures need to be taken. This should all be adequate and proportional. Thus, not doing nothing at all, but also not strengthening things up to, for instance, ten times the current standard. If this does not happen, damages arise which must be compensated for due to liability based on fault, because the controlling authority fails performing its duty to care;
- 2 *Not acting/omission*. For instance, no inspections are performed, or no action is taken upon complaints, warnings or inspection results with the controlling authority's knowledge that the standards have not been met everywhere. When something goes wrong, the chances are high that the occurring damage must be compensated for due to liability based on fault, because the controlling authority fails to fulfill its duty to care;
- 3 *Faulty flood defense system*, meaning the occurring damage must be compensated based on strict liability for faulty buildings.

### **When damage has to be compensated as a result of failure to fulfill the duty to care on the part of the controlling authority**

Prior to compensation for damages resulting from a failure to fulfill the duty to care on part of the controlling authority, a number of requirements must be met:

- *Unlawful act or omission*. This may arise in two situations:
  - Act: the controlling authority does take measures, but fails to implement them adequately (for instance, executing poor inspections, responding inadequately to inspection results, not making sufficient improvement in a technical aspect);
  - Omission: the controlling authority fails to take adequate measures or fails to respond to signals (for instance, the inspection results).
- In the case of an unlawful act, there must be an *attributably wrong behavior* (breach of the behavioral standard).
- The damage that has arisen as a result of this unlawful act or omission (*causality*).
- The damage and the unlawful acts or omissions must be attributable to the controlling authority, and
- The behavioral standard that is breached by the flood defense system controlling authority must also be intended to protect the interests of the person who has incurred damage.

It will differ in each case whether all requirements have been met..

## BEHAVIORAL STANDARDS OF A FLOOD DEFENSE SYSTEM CONTROLLING AUTHORITY

The behavioral standards of a controlling authority are:

- 1 The *duty to care* for water security (= the most important behavioral standard). This duty to care is a best-efforts obligation, which entails doing everything reasonably possible to meet the standards of water security. By violating the duty of care, in principle, measures may be enforced by individuals.
- 2 *Control* that is based on the standards established. If the standards are not met, measures have to be taken. These measures are mainly based on control plan, in which the duty to care are described in detail in terms of time, location and regional conditions, and in which account is taken of the practical, technical and financial options.

The rationale is that if the controlling authority performs its duties in accordance with these behavioral standards, nothing can go wrong. In other words, if something has gone wrong resulting in damage, the controlling authority has not taken adequate measures, or has poorly planned or implemented them.

## EXPERIENCE AND DISCRETIONARY POWER

Furthermore, the personal characteristics of the “culprit” are important. In the case of flood defense systems, it is about experience, knowledge, skills, and capability that play a role. In the case of government bodies, it is also important that they have a certain amount of discretionary power. That is inherent to the administrators chosen. They do not want to burden landholders with unreasonable costs and things that technically and practically cannot be solved right away. Not everything is achievable in the short term, so priorities must be set, which is perfectly fine.

## Meaning and consequences of the Wilnis ruling and putting absolute and risk-based liability into perspective

Since the ruling of the Supreme Court in the Wilnis case, most hydraulic structures in hands of the state, such as dikes, peat dikes, sluices, pumping plants, and dams fall within the scope of the legal definition of buildings. This means that risk-based liability lies with the owner, and that the question of culpability does not apply. Yet, the Supreme Court has left room in its ruling. Not every owner can be held liable for all damages. The Supreme Court has cited a number of criteria that can be used to determine whether or not an owner can actually be held liable in specific cases. These criteria are vague and abstractly formulated, but they nonetheless offer guidance to the question whether or not any limitations apply to the liability.

In the first place, the '*given circumstances*' are important. These circumstances both concern the 'normal situation' and special situations or calamities. The performance of duties on the part of the controlling authority plays a role in this as well. Relevant aspects named by the Supreme Court include:

- Nature and purpose of the buildings (for instance, a publicly accessible dike, or not);
- (Guarantee) function of the building (protection of local residents against water);
- The physical condition when the danger occurred (inspection);
- The foreseeability of the failure and associated danger according to objective standards. *The flood defense system controlling authority should therefore be informed about new scientific developments and practical options that can be applied to the actual practice of control;*



- The option and inconvenience of measures to be taken;
- The discretionary power and the available financial means.

This is assessed in view of the 'then state of affairs and the state of the art and the actual option to take adequate security measures'.

#### **How liability can be avoided**

- *Controlling authority (whether owner or not)*. To the controlling authority, it applies that its flood defense systems have to meet the standards in time that it has adequate control plans in place and that it takes the necessary measures in time. It is important to keep up to date with the professional literature about the vulnerability of the flood defense systems (Wilnis) and new technologies. It is also advisable to allow room for innovation, but with due care and caution, because it is not wise to experiment with high risks. Finally, an adequate response to complaints and/or inspection results is of the utmost importance.
- *Owner/non-controlling authority*. It has to ensure being alert to liability and it must obtain information from the controlling authority about the technical state of the dike of which it owns a part. If the dike does not meet the requirements set - the dike is considered to be faulty - it is advisable to confront the controlling authority about its duty to care.

## ANNEX A

# CONCLUSIONS OF THE DUTCH SAFETY BOARD AS A RESULT OF THE QUAY BREACH AT STEIN (JANUARY 2004)

The Dutch Safety Board analyzed the quay breach near Stein (January 2004). The assessment framework is relevant to the inspections of the flood defense systems (see also [http://www.onderzoeksraad.nl/docs/rapporten/Rapport\\_leidingbreuk\\_Stein.pdf](http://www.onderzoeksraad.nl/docs/rapporten/Rapport_leidingbreuk_Stein.pdf)).

## 2.2. Assessment framework for safety management

The past has shown that structure and execution of the safety management system play a crucial role in the appointment expedient management and continuous improvement of safety. For the Safety Board important points are:

- a) Demonstrated commitment to the policy to prevent unwanted events in which the general objectives and principles are included to prevent and control the identified adverse events. This is an explicit relationship to be established between the laws and regulations; the current industry standards for safety and objectives specifically designed for those in charge.
- b) A description of how to implement the policy and put it into effect, defined objectives, plans and consequently preventive measures.
- c) Unique allocated responsibilities for the implementation of security plans and measures, and clear and active central coordination of safety activities.
- d) A system of monitoring and investigation of incidents, near misses and accidents, as well as expert analysis of these to make possible a streamlining of the planning cycle.
- e) Periodical performance of (risk) analyzes, observations, inspections and audits to bring improvements which can be actively approached.
- f) Clear and established agreements with the surrounding community on general procedure, method of assessments, procedure deviations, etc.
- g) A periodic review and possible adjustment by the management (management review) of the safety policy.



## ANNEX B

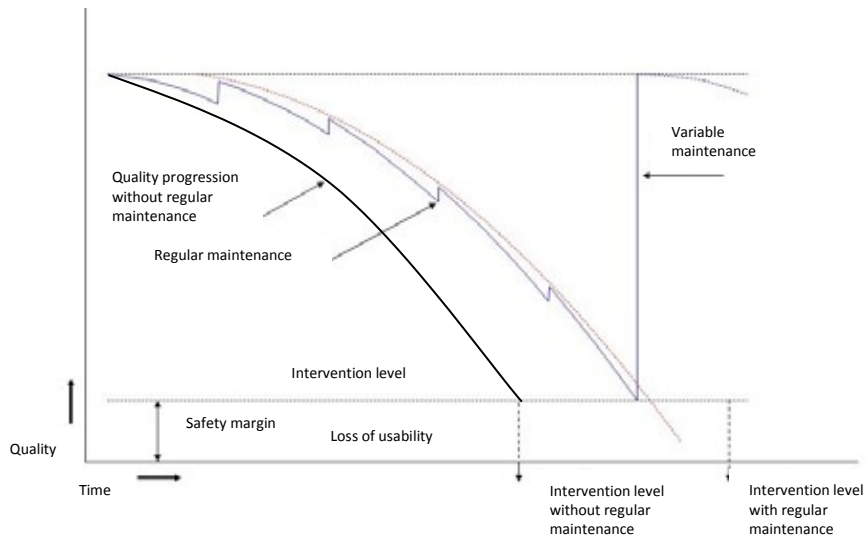
# EXAMPLES OF NEED FOR INFORMATION

Each client of the inspection process has a particular need for information which links up with the underlying process and mechanisms. For two clients, this has been detailed in the example: maintenance and enforcement

## INSPECTION OBJECTIVES FOR MAINTENANCE

Figure B.1 gives a schematic overview of the choices at particular maintenance times: fixed and variable, or none. Inspections serve to substantiate the correctness of these choices, to determine the right moments at which maintenance should be performed and the moment at which the intervention level is reached. Furthermore, the inspections determine the scope of the maintenance.

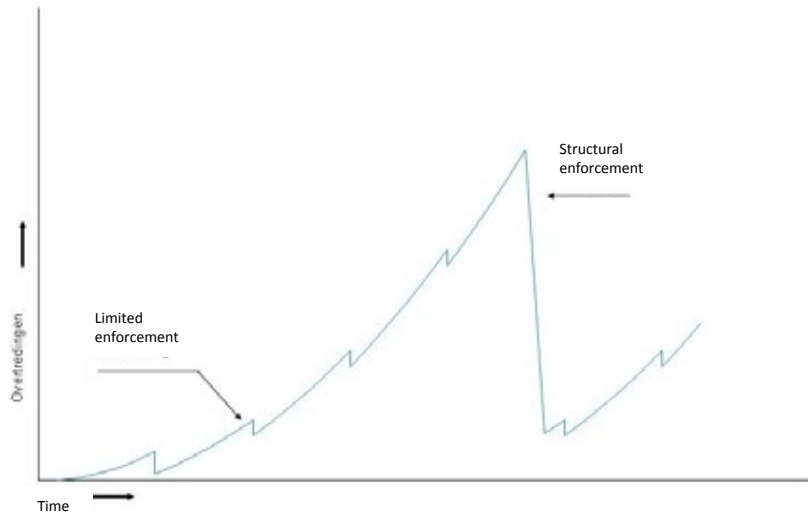
FIGURE B.1 QUALITY DEVELOPMENT ELEMENT OF THE FLOOD DEFENSE SYSTEM



## INSPECTION OBJECTIVES FOR ENFORCEMENT

Flood defense systems mostly serve a multifunctional purpose. It is of the utmost importance that this joint use is regulated, so that the primary function of the hydraulic structure, keeping water out, is guaranteed. Enforcement is aimed at regulating this joint use. Figure B.2 gives an indication of this. If, for example, in the case of limited enforcement, the number of non-licensed excavations at a flood defense system becomes a point of concern, the inspections show that the number of observations increases. This information may suggest to enhance the goal of enforcement on this aspect (the structural enforcement), so that the number of violations decreases drastically.

FIGURE B.2 DEVELOPMENT IN OBSERVATIONS AND INFLUENCE OF INTENSIFICATION



ANNEX C

# EXAMPLES OF REFERENCE MAPS FOR VISUAL INSPECTIONS

## C.1 REFERENCE MAP OF VISUAL INSPECTION BY THE WATER BOARD RIVIERENLAND

Conducting inspections	
<p><u>Conditions:</u></p> <ol style="list-style-type: none"> <li>1. drafting an inspection plan including a data management structure</li> <li>2. drawing up clear working instructions</li> <li>3. determining reference images</li> <li>4. having knowledge of flood defense systems</li> </ol>	<p style="text-align: right;"><u>Preparation:</u></p> <ol style="list-style-type: none"> <li>1. collecting information about inspection course</li> <li>2. preparing equipment (or forms)</li> <li>3. making agreements about data submission</li> <li>4. determining how to best move on</li> </ol>
<div style="border: 1px solid black; padding: 10px; width: fit-content; margin: 0 auto;"> <p><b>GOAL-ORIENTED</b></p> </div>	<p style="text-align: right;"><u>Use:</u></p> <ol style="list-style-type: none"> <li>1. registration form or computer</li> <li>2. pricker</li> <li>3. reference map/measuring tape</li> <li>4. camera (with GPS)</li> </ol>
<p><u>Implementation:</u></p> <ol style="list-style-type: none"> <li>1. working in a structured manner</li> <li>2. using the circumstances</li> <li>3. choosing the visual process (how to traverse the dike)</li> <li>4. inviting other to the inspection</li> </ol>	

Digiguide system for visual inspections of flood defense systems	
<p><b>1) Identify the type of flood defense system</b></p> <ul style="list-style-type: none"> <li>- sea dikes</li> <li>- dunes</li> <li>- river dikes</li> <li>- regional flood defense systems</li> </ul>	<p><b>2) Identify the zone</b></p> <p>For dikes:</p> <ul style="list-style-type: none"> <li>- Foreland</li> <li>- Foreshore</li> <li>- Outer slope</li> <li>- Crown</li> <li>- Inner slope</li> <li>- Stability bank</li> <li>- Maintenance strip</li> <li>- Ditch at the foot of a slope</li> <li>- Piping bank</li> <li>- Hinterland</li> </ul> <p>For dunes:</p> <ul style="list-style-type: none"> <li>- Foreshore/beach</li> <li>- Beach</li> <li>- Dune front</li> <li>- Dune area</li> </ul>
<p><b>3) Identify the material:</b></p> <ul style="list-style-type: none"> <li>- Natural soil</li> <li>- Grass covering</li> <li>- Stone covering (columns and blocks)</li> <li>- Asphalt covering</li> <li>- Rock filling</li> <li>- Transfer constructions (kerbs)</li> <li>- Sheet pile walls/shoring</li> <li>- Roads (asphalt, clinker)</li> </ul> <p>etc.</p>	<p><b>4) Identify the inspection parameter</b></p> <ul style="list-style-type: none"> <li>- bare spots</li> <li>- cracks</li> <li>- subsidence or bulging</li> <li>- rutting</li> <li>- digging</li> <li>- weeds</li> <li>- missing rocks etc.</li> </ul>
<p><b>5) Identify the quality of the material</b></p> <ul style="list-style-type: none"> <li>- good</li> <li>- reasonable</li> <li>- poor</li> <li>- bad</li> </ul>	<pre> graph TD     A([observation]) --&gt; B([diagnosis])     B --&gt; C([prognosis])     C --&gt; D([operationalization])     D --&gt; A     </pre>

10 x 10 cm.

10 x 10 cm.

(1 x 1 cm)

5

10

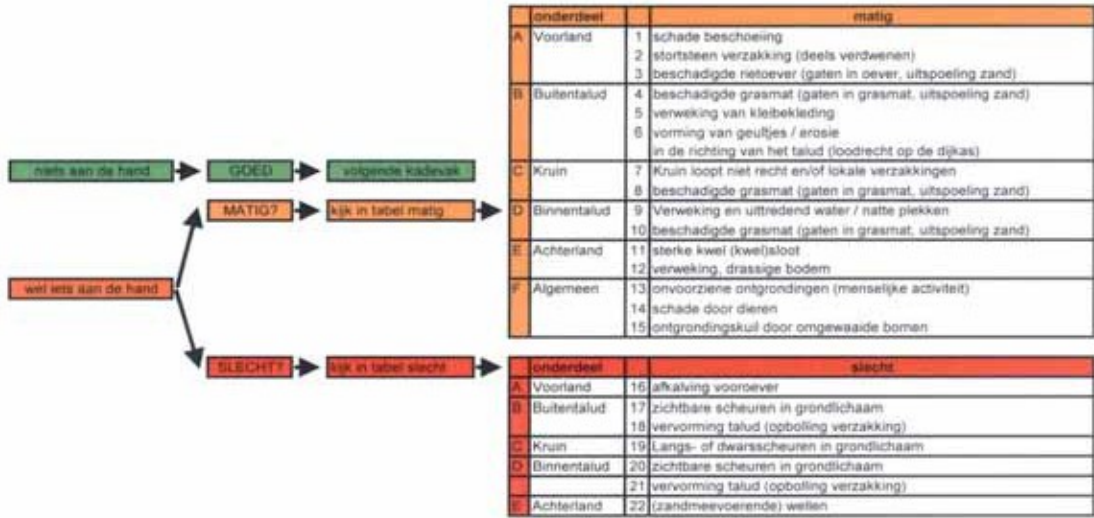
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**c.1 STEP-BY-STEP PLAN FOR VISUAL INSPECTIONS OF WETTERSKIP Fryslân (2007)**

**VISUAL QUAY INSPECTION**



**WATER BOARD BY-LAW ASPECTS**

Adopt
1. Fighting game that the water retaining capacity vn flood damages, except muskrat;
2. Keeping clear of debris, objects and materials;
3. The repair of minor damage such as caused by traffic, cattle and the like;
4. Reporting to the board of significant organ damage;
5. Maintaining the coatings and vegetation serving to defend the dam;
6. Keeping clear of brushwood, including thistles and nettles.





## ANNEX D

# STEP-BY-STEP GUIDE FOR SETTING UP AN INSPECTION PLAN

## 0. PREPARATION

- 1 *Project proposal.* Write a project proposal 'drafting an inspection plan'. Describe the assignment, approach, project organization, project implementation, project planning, decision moments and the required budget.
- 2 *Adopt project proposal.* This may seem obvious, but experience in the pilot studies has shown that it is of little use to work on an inspection plan if the initiative is not supported by the organization. Chances are that the initiative will not be implemented.

## A. BASELINE SITUATION

- 3 Describe the area. State which flood defense systems are to be inspected:
  - *Primary flood defense systems*, broken down into category (A, B and C) and standard.
  - *Regional flood defense systems*, broken down into basin quay, compartmented flood defense systems, fore-quays and land-quays, quays along regional rivers + associated standards.
  - *Other flood defense systems*: flood defense systems that are under control, but are neither designated or standardized, for instance quays along high water circuits.

The exact location of these flood defense systems and any other information may be included in annexes.
- 4 *Description of the baseline situation.* Describe the structure and implementation of the current inspections. In this phase, the available annual budget for inspections is mapped.
- 5 *Determine the weak and strong points of the baseline situation.* Make use of the operational objectives:
  - Reliable results;
  - Reproducible results;
  - Standardized instruments;
  - Standardized working methods;
  - Implementing the planned activities;
  - Implementing the planned activities well;
  - Employees being result- and organization-oriented.

Another option is to describe the desired structure and implementation of the inspections.

- 6 *Verify the analysis results* via internal and external testing of the results. Do not hesitate to question all parties involved: 'From field inspectors to board/controlling authority' and all other layers of involved parties.

## **B. DESIRED SITUATION**

- 7 *Determine the objectives of the inspection*, including an indication of budgets. In this step, it is determined in consultation with the management which objectives are further worked out in the inspection plan.
- 8 *Determine the types of inspection*: objective, frequency, period, aspects to be observed, manner of documentation.
- 9 *Determine the desired situations* (technical and outward appearance) of the desired state of maintenance per category of flood defense system.

## **C. IMPROVEMENT PLAN**

- 10 *Identify* the actions for improvement;
- 11 *Prioritize* the actions for improvement;
- 12 Draw up an overall *planning* for all actions for improvement;
- 13 *Implement* the actions with the highest urgency in the next inspection cycle;
- 14 *Evaluate* this inspection and adjust the overall planning to the results.

## ANNEX E

# CHECKLIST FOR ESTABLISHING THE BASELINE SITUATION

Staff	Observation	Diagnosis	Prognosis	Operation
Training and knowledge	<p>Observers are able to detect, recognize and interpret quality. Therefore:</p> <ul style="list-style-type: none"> <li>• Civil Engineering on an intermediate vocational level.</li> <li>• Courses Dike Inspector 1 and 2, Visual Inspections</li> </ul>	<p>Staff is able to make diagnoses</p> <ul style="list-style-type: none"> <li>• Civil Engineering on a university of applied sciences level.</li> <li>• Additional education in hydraulic engineering of flood defense systems.</li> <li>• Able to hire specialists (for instance, soil mechanics).</li> <li>• Knowledge of inspection techniques</li> </ul>	<p>Staff is able to make prognoses:</p> <ul style="list-style-type: none"> <li>• Knowledge about failure and collapse mechanisms, ageing processes, and risk analysis at university level in applied sciences</li> </ul>	<p>Staff has knowledge of maintenance work the contents of the current and historical long-term maintenance</p>
Knowledge exchange	<ul style="list-style-type: none"> <li>• A joint preparation meeting before the inspection round.</li> <li>• A joint evaluation after the inspection round.</li> </ul>	<p>Knowledge exchange with other controlling authorities.</p>	<p>Knowledge exchange with other controlling authorities.</p>	<p>Evaluation with people performing maintenance, enforcement and information management.</p>
Relations	<ul style="list-style-type: none"> <li>• Staff is aware of the structure of the inspection process through training, information meetings etc.</li> <li>• Experiences are frequently and in a structured manner exchanged between subprocesses.</li> <li>• Feedback is given regarding results from next subprocesses.</li> </ul>	<ul style="list-style-type: none"> <li>• Staff is aware of the structure of the inspection process through training, information meetings etc.</li> <li>• Experiences are exchanged with other flood defense system controlling authorities, inside and outside the organization.</li> <li>• Experiences are frequently and in a structured manner exchanged between the subprocesses.</li> </ul>	<ul style="list-style-type: none"> <li>• Staff is aware of the structure of the inspection process through training, information meetings etc.</li> <li>• Experiences are exchanged with other flood defense system controlling authorities, inside and outside the organization.</li> <li>• Experiences are frequently and in a structured manner exchanged between the subprocesses.</li> </ul>	<ul style="list-style-type: none"> <li>• Linking inspection process to the budgeting and enforcement process.</li> </ul>
Structures	<ul style="list-style-type: none"> <li>• Standardized working method, laid down in procedures and instructions.</li> <li>• Procedure for control of accuracy and accuracy of the data obtained</li> <li>• Instruction for documenting data.</li> <li>• Procedure for the transfer of data.</li> </ul>	<ul style="list-style-type: none"> <li>• Procedure for transfer of data.</li> <li>• Standardized working method, laid down in procedures and instructions.</li> <li>• Instruction for documenting data.</li> </ul>	<ul style="list-style-type: none"> <li>• Procedure for transfer of data.</li> <li>• Standardized working method, laid down in procedures and instructions.</li> <li>• Instruction for documenting data.</li> <li>• Instruction for feedback about the results to those making observations and diagnoses</li> </ul>	<ul style="list-style-type: none"> <li>• Procedure for structured and recognizable transfer of the observation of observations</li> <li>• Determined procedure for the manner of follow-up and feedback regarding results.</li> <li>• Instruction for determining the desired follow-up based on standards</li> </ul>

People	Observation	Diagnosis	Prognosis	Operation
Systems	<ul style="list-style-type: none"> <li>• Adopted inspection plan</li> <li>• Instructions for performance of observations.</li> <li>• Standard formats for documenting observations.</li> <li>• Means to document observations and save in a univocal manner</li> <li>• Observations are linked to geographical data.</li> <li>• There is an overview of the determined observations.</li> <li>• Observers have about sufficient tools for making observations and documenting them.</li> <li>• There is room for remarks of the inspector.</li> </ul>	<ul style="list-style-type: none"> <li>• Basic data as Register and control register are up-to-date, contain historical data (maintenance, observations and notifications), are accessible and digital.</li> <li>• There are sufficient data about the subsoil and structure of the flood defense</li> <li>• Determined and univocal standardization and evaluation.</li> <li>• Determined categorization of and definition and procedure of follow-up.</li> <li>• Availability of complete and relevant area information</li> </ul>	<ul style="list-style-type: none"> <li>• Result of diagnosis in a structured manner laid down, accessible and reproducible.</li> <li>• Have access to current maintenance planning, historical data, good area information documented in digital control register.</li> <li>• Documenting of the prognosis in information system and control register.</li> </ul>	<ul style="list-style-type: none"> <li>• Digitally accessible information system with all relevant information about the observation.</li> </ul>

## ANNEX F

# THE INSPECTION IN GREATER DETAIL

This annex provides a description of actions to be completed per subprocess of an inspection. Table F.1 provides an overview.

**TABLE F.1**      **QUALITY OF THE INSPECTION PER SUBPROCESS**

Process step	Quality requirements
Observation	Standardized working method (laid down in procedures and instructions) Instruction for documenting data. Procedure for check for accuracy and completeness of the data obtained. Procedure for the transfer of data.
Diagnosis	Availability of relevant and validated data Standardized processing (laid down in procedures and instructions) Instruction for the documentation of information. Procedure for the transfer of information.
Prognosis	Availability of relevant data. Standardized working method (laid down in procedures and instructions) Instruction for documenting information. Procedure for the transfer of information to interested parties and parties involved.
Operationalization	Availability of inspection results. Formulation of actions from inspection results. Prioritizing actions. Agreements about delivery inspection (separate from/during the next inspection).

## F.1 Observation

For an accurate description of the current and functional state of the flood defense systems, the following aspects of observations must be taken into consideration:

- 1 Documenting the general data:
  - Name of inspector;
  - Time: day, month, year;
  - Place: coordinates;
- 2 Observation technique used
  - Visual;
  - Sensor in the dike;
  - Remote sensing (for instance, airplane);
- 3 Standards for characterizing damage (see Tables F.2 and F.3):
  - Digiguide;
  - Own damage catalogue;

- 4 Documenting the damage situation:
  - Place in the profile;
  - Height and size;
  - Presence of unwanted vegetation;
  - Damage caused by animals (moles, rabbits, mice, muskrats);
  - Length of presence/intensity;
- 5 Determining the state of maintenance:
  - Grass;
  - Bank protection
  - Rock filling;
  - Asphalt covering;
  - Fences etc.;
- 6 Determining the quality category of the observation (see Table F.2);
- 7 Determining the urgency category of the observation (see Table F.3);
- 8 Documenting information:
  - In Diginspection (in the field);
  - On photos (1 overview and 1 detailed photo, location via GPS, date, time);
  - Processing information at the office in the Control Register.

**TABLE F.2 DIGIGUIDE QUALITY CATEGORIES**

Quality category	Description
<b>Good</b>	The element fully meets the constructive and functional requirements
<b>Reasonable</b>	The element sufficiently meets the constructive and functional requirements
<b>Fair</b>	The element no longer sufficiently meets the constructive and functional requirements
<b>Poor</b>	The element does not meet the constructive and functional requirements

**TABLE 3.3 URGENCY CATEGORIZATION OF DAMAGE**

Urgency category	Description
<b>Category 1: emergency repairs</b>	The detected deviation puts the flood defense system's strength/stability at immediate risk. Repairs have to be made immediately (within 1 - 2 days).
<b>Category 2: Urgent repairs</b>	The deviation observed does not put the flood defense system's strength/stability at immediate risk. However, the deviation may deteriorate in the short term which would jeopardize the stability or which may result in significantly higher repair costs. Repairs need to be performed urgently (within 1 - 2 months).
<b>Category 3: repairs before the closed season</b>	The deviation observed does not put the strength/stability of the water-retaining structure at immediate risk and does not have the potential to deteriorate in the short term. However, the deviation does put the flood defense system's stability at risk under normative conditions. Therefore, repairs have to be performed before the start of the closed season.
<b>Category 4: Prognosis</b>	The deviation observed does not put the flood defense system's stability at immediate risk, does not have the potential to deteriorate in the short term and the dike's strength/stability is not jeopardized under normative conditions. Repairs can be made in the long term. A further <i>prognosis</i> has to be drawn up.

## F.2 DIAGNOSIS

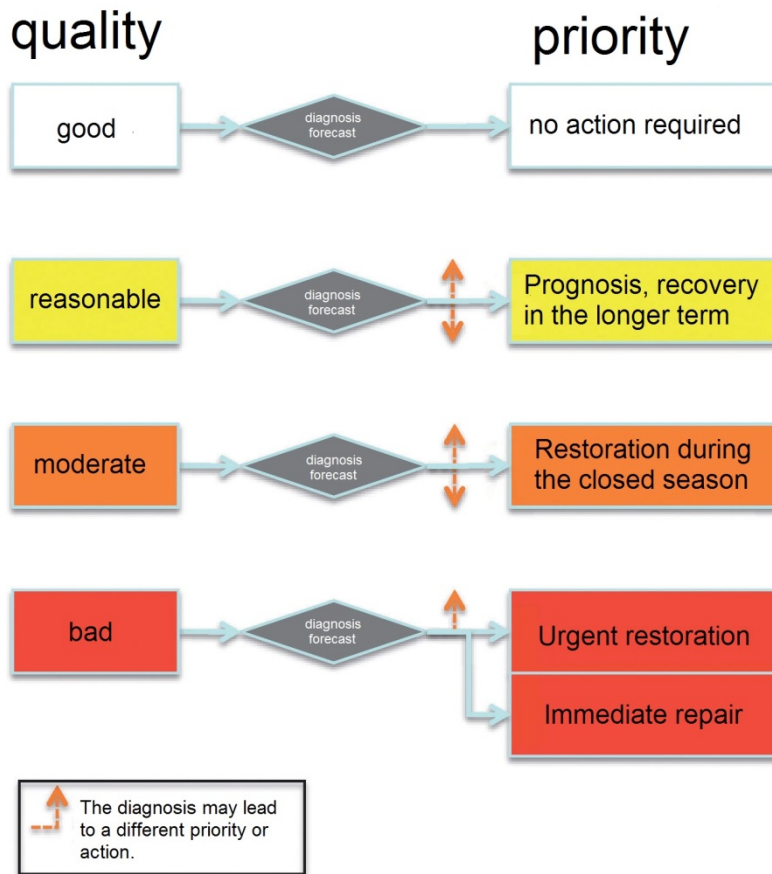
In order to draw up a diagnosis, the data from Tables F.2 and F.3 are combined with the data from Table F.4 and Figure F.1. This results in:

- Categorization in relation to the urgency of the required actions/measures. For instance, within six months, see overview in Figure F.1;
- Maintenance and enforcement requirements per location. If necessary, including emergency measures;
- Extra notes in the case of a recurring damage situation. This information is documented in the control register.

**TABLE F.4 DATA REQUIRED FOR THE DIAGNOSIS (SEE ALSO ANNEX G)**

Component	Data
<b>Geometry</b>	Shape, crest height, settlements, subsidence, 'non-damming objects'
<b>Embankment</b>	Structure, type of soil, deeper sub-soil, non-damming objects (such as cables and pipelines), holes (moles, mice, beavers, foxes, rabbits, etc.)
<b>Groundwater</b>	Groundwater levels and rise levels, water content (peat dikes)
<b>Coverage</b>	
Grass	Root density, cracks, control form (mowing, grazing, etc.), presence of unwanted plant species
Stone	Stone types, crests, crown, wood cover, presence and quality of filter layer
Asphalt	Thickness, cracks, rigidity, emerging vegetation, stripping, holes
<b>Load</b>	<i>Normative conditions:</i> water levels, wave height, volume of overtopping and overflow, rates of flow, duration <i>Daily circumstances:</i> drought, traffic load, cattle
<b>Surroundings</b>	nature of the protected area, type of open water, presence of shipping traffic, etc.
<b>Testing</b>	Are there relationships between deviations observed and results from the latest safety tests? For instance, is there a link between damage due to the failure mechanism that resulted in an insufficient score in the test?
<b>Data from previous inspections</b>	Is the deviation observed the first one or has the deviation been observed in previous inspections? If yes, can a pattern be discerned?

**Figure F.1 Relationship between quality and urgency categories**





### F.3 PROGNOSIS

In order to determine the developments across time for the Category 4 damage situations (see Table F.3), the following aspects apply:

- 1 How is the phenomenon developing, for instance, subsidence or oxidation in relation to the size of the pile cap? It is important to include the composition of the dike and the subsoil (peat, clay, sand). Account must also be taken of more large-scale developments, for instance soil subsidence due to development of gas fields, developments in the normative water level or wave characteristics and/or standard upgrading, as a result of an increase in invested capital. External experts may need to be hired;
- 2 Draw up a long-term preview of the maintenance planning (regular - annual/major repairs);
- 3 Draw up an overview of the consequences of the prognosis for possible control actions and for calamity services;
- 4 Register this overview in the control register.

### F.4 OPERATION

Draw up a clear overview of the damages observed/enforcement actions and the necessary measures to bring the flood defense systems to the required standards. This requires the following data:

- 1 Location;
- 2 Type of measure;
- 3 Urgency of the execution/prioritization.

It must be agreed how to handle the inspection of the repair work:

- On delivery;
- At the time of the next regular inspection.

## ANNEX G

# DIAGNOSTIC TECHNIQUES

## G.1 DATE OF GEOMETRIC PROFILE

The following qualities are important for the geometric profile:

- Crest height of the flood defense system;
- The x, y, and z coordinates of the flood defense system's profile (crest width, slope of an embankment, height/width of rubble banks, rise of the embankments, etc.).

The controlling authority is mainly interested in changes in size of these qualities. These may occur due to:

- Subsoil settling;
- Settling of the dike;
- Settling and shifts, for instance due to instability of the subsoil caused by piping or natural gas field development.

### HEIGHT MEASUREMENTS OF FLOOD DEFENSE SYSTEMS

Changes in height of a dike are difficult to spot with the naked eye. Therefore, height measurements/checks with the AHN2 are required. Substantial local settling can be seen with the naked eye.

Height measurements are executed at different frequencies. The frequency is high immediately following the construction of the dike in order to monitor settling and anchoring. The frequency may decrease if the level of settling and settlement is minor. For primary flood defense systems, the frequency equals the testing frequency (now, once every six years). For regional flood defense systems, this standard for inspection of the height has not yet been determined.

## G.1 INSPECTION VARIABLES OF FLOOD DEFENSE SYSTEMS

Inspection variables and important aspects of profiles of artificial flood defense systems are depicted in the tables below, which have been taken from [Inventory of information requirements of the flood defense system controlling authorities/dike deformation, Ministry of Transport, Public Works and Water Management, Geometric Department, January 2003].

Table G.1 Inspection parameters of profiles of flood defense systems and related aspects

Inspection parameter	Significant unit	Accuracy	Inspection frequency	Spatial distribution	Explanation
Profile of the flood defense system (including crest height)	cm	Z coordinate: $\pm 0-5$ ; X- and Y coordinate: 0-10 cm.	Standard: Every five years; for new flood defense systems susceptible to settlement: annually or every few months.	Very diverse, from 10 – 500 m.	Height, width, length.
Occurrence of settlement and subsidence	mm, cm	Z coordinate: $\pm 0-5$ ; X- and Y coordinate: 0-10 cm.	Standard: Every five years; for new flood defense systems susceptible to subsidence: annually or every few months.	Depending on the subsoil. Difference in settlements must be made clear: 20 – 100 m.	Difference in height across time.
Height of rubble bank for the flood defense system	dm	Z coordinate: $\pm 10-20$ cm	Standard: Annually, depending on the situation sooner or later.	Every 100 m, sometimes closer to 50 m (in case of special circumstances).	Low reliability is accepted, because of the presence of different heights in large amounts of rubble
Composition of soil/structure of the soil layers	in centimeters	Deviation from laboratory analysis.	Once at construction	Covering the area	The error margins used in the lab are accepted
Groundwater levels in the flood defense systems	in centimeters	$\pm 5-10$ cm.	Depends on the area. Sometimes, more times per day for a number of days (season). In the case of high water.	Depending on the subsoil and the objective.	The groundwater level is viewed as indicative. Often with open pipe piezometers
Structure of the foreshore	in dozens of m <sup>3</sup>	$\pm 5-10$ cm	Annually within the framework of coast measurements and after storms.	10-100 m along the shore. Every meter in the cross section perpendicular to the shore.	Course of the foreshore
Presence of non-flood defense systems		Has to demonstrate the objects present	2 to 4 times per year.	Covering area: all objects.	Houses, trees, gardens, fences, etc. Actual situation must be known. It is desirable to monitor any changes and to intervene if they are illegal (enforcement).

### G.3 DATA OF DUNES

The profiles of dunes have to be measured every year. Together with the beach, dunes form the defense structure from sea water. They form a flexible and dynamic defense system that is subject to continual change and therefore needs to be inspected well.

The state of the natural flood defense system is assessed based on the following qualities or parameters:

- Volume (in m<sup>3</sup>) sand in the dune profile;
- Chances of seepage through a row of dunes;
- Presence of dusting holes;
- Level of erosion of the coastline;
- Stability of the groynes;
- Quality of the marram grass present (grass retains the sand of the dunes).

Inspections are usually conducted visually. For height determination in the inspections of foreshores and dunes technical tools are used. Table G.2 shows the parameters and aspects that are important to dune inspections.

**TABLE G.2 INSPECTION PARAMETERS FOR DUNES AND RELATED ASPECTS**

Inspection parameter	Significant unit	Accuracy	Inspection frequency	Spatial Distribution	Explanation
Amount of sand in dunes	Several m <sup>3</sup> tens of m <sup>3</sup>	x, y, z coordinate: ±5-10 cm.	Standard: Annually, with the help of Jarkus	Every 200 -250 m red hempnettle	The x, y, z coordinates are important for volume calculation. An accurate calculation allows for a deviation of several m3. Three-dimensional images are welcome
Presence of dusting holes	m <sup>3</sup>	x, y, z coordinate:	Annually, in the case of dynamic dune control: 2 to 3 times per year	Covering the entire area.	Undermining bare spots in row of dunes.
Quality of the marram grass	Length, density	+ 5 cm. grass blades per m <sup>2</sup>	Annually.	Covering the entire area.	Health of the plants, color and strength, season-dependent. No reliability or accuracy can be given
Erosion of the coastline(foreshore)	Several m <sup>3</sup> .	z coordinate: ±5- 10 cm.  –	Annually.	Along the coast, every 10 x 100 m Cross section and then every other meter,	Underwater measurements.
Seepage of rows of dunes	mm/day and m <sup>2</sup> .	Unknown	Annually, in the case of dynamic dune control: 2 to 3 times per year.	Covering the area.	Low spots in the row of dunes. In the case of storms, the sea may seep through the first row and reach the second row of dunes
Stability of the groynes	Unknown	Unknown	Twice per year, before and after the storm season.	Each groyne.	Groynes ensure the protection of the coastline. Difficult to inspect because they are mainly located under water.

## G.4 COVERAGE

The embankments of the sea and lake dikes are covered to provide protection from damage and erosion. Three groups of coverage can be discerned: grass coverage, stone coverage (also concrete and concrete poured slopes fall in this category) and asphalt and asphalt poured slopes. Per type of coverage, the following qualities can be discerned:

- Grass;
- Level of cover of the grass strip (bare spots, thickness of the grass strip);
- Quality (including clump forming, color, diversity);
- Root penetration of the grass strip (turf);
- Grazing of the grass strip (turf).

Rodents may also be or become the cause of damages to the grass strip. This also applies to the presence of wood cover (large) litter and other vegetation types. Early identification is therefore important.

Parameters and aspects that may be important for inspection of the grass coverage are summarized in Table G.3.

TABLE G.3 INSPECTION PARAMETERS FOR GRASS COVERAGE AND RELATED ASPECTS

Inspection parameter	Significant unit	Accuracy	Inspection frequency	Spatial distribution	Explanation
Cracks	Length and width of the crack: in cm	Unknown: $\pm 0 - 5$ cm?	Varying, from every few months to annually	Covering the entire area	Cracks caused by continuing drought. Hard to detect because cracks may be covered by grass
Closed grass cover	in percent	For instance, 20 cm of open ground per m <sup>2</sup> . Spots of 2 to 30 cm must be detected.	Varying, monthly to annually. After high water.	Covering the entire area, Large patches	Large bare spots. Inspections conducted of large pieces. Open areas between grass fields? Can you see the soil? Can it be washed away? Visual inspections. Instinct-driven.
Quality of the grass cover (for instance, damage caused by high water, clumping, unhealthy grass)	Unknown. See explanation	Hard to make concrete. Is executed by experts. Monitoring the entire area and doing spot-checks.	Varying, from every few months to annually. After high water	Covering the area.	Suffocation caused by long-term high water. Pollen in the grass that cause bare spots around the clump. Health and vitality of the grass
Species diversity	Number of types of crops per surface area unit (m <sup>2</sup> )	Unknown	Usually every five years.	Covering the entire area	Different types of herbs and grass are present in the grass cover. The significant unit
Presence of moles, rabbits, muskrats and river rats	Unknown. See explanation.	Unknown. See explanation.	Varying, from daily to every few months.	Covering the entire area	These rodents dig in the grass cover. At high water, a part is swept away, causing damage. The significant unit and accuracy cannot be described, because the presence of damage must be detected
Root penetration	Many thick and thin roots in the upper soil layer (see LTV).	According to the LTV. method.		The upper 20 cm of the grass strip, 4 spot-checks in squares of 5 by 5 meters (entire dike must be divided into these squares).	Shows the strength and resilience of the grass strip. Level of presence of thin and thick roots in the soil layer of the natural soil up to 0.15 cm m-mv (see LTV.).
Control form	Fertilization and removal of grass.	10 m <sup>2</sup>	Weekly up to monthly or every few months.	Covering the entire area.	Cattle damages the turf, sheep does not. Important in the context of maintaining.

## G.5 STONE COVERING

The following parameters are important for stone covering (see also Table G.4):

- Hollow spaces and the development of sludge underneath the covering;
- Missing stones from the covering;
- Subsidence or rise of stones, crests and shifts of the covering.

**TABLE G.4 INSPECTION PARAMETERS FOR STONE COVERAGE AND RELATED ASPECTS**

Inspection parameter	Significant unit	Accuracy	Inspection frequency	Spatial distribution	Explanation
Hollow spaces and the development of trenches underneath the stones	cm	Settling from 2 cm	Varying, from bi-weekly to annually. After each calamity	Covering the area	Hollow spaces underneath the stones undermine the covering. Erosion takes place underneath the stones which undermines the dike. Requirement: observation from 2 cm depth. It often becomes clear by the subsidence of the basalt. However, this does not always happen.
Subsidence, crests and shifts of the covering	cm	± 0 - 5 cm	Varying, from bi-weekly to annually, to five-annually. After each calamity	Covering the area	Subsidence, crests and shifts of the covering can often be spotted with the naked eye. Except in the case of slow developments.
Lack of paving stones	cm	X-, Y- and Z-coordinates: ± 0 - 5 / 10 cm. Each stone.	Varying, from bi-weekly to annually. After each calamity	Covering the area	Stones removed from the slope. Each stone must be inspected, as numerous stones can be swept away.
Presence of wood cover and other vegetation	Presence thereof.	Presence thereof	Varying, from bi-weekly to annually. After each calamity	Covering the area	Presence is often sufficient to remove it. Wood cover may undermine the covering and result in erosion at high water.
Rise of the covering	cm	± 0 - 5 cm.	Varying from bi-weekly to annually. After each calamity	Covering the area	The form of the covering (round).
Cover areas	Exact boundary of the one to the other plane.	Exact boundary (often difficult if different column lengths alternate.)	Single measurement.	Covering the area	Is connected to subsidence, crests and shifts of the covering.

## G.6 ASPHALT

Important characteristics of the quality of asphalt are:

- Development of cracks in concrete or asphalt;
- Occurrence of fraying;
- Occurrence of stripping;
- Thickness of the asphalt;
- Rigidity of the asphalt;

The slope coverings are regularly inspected by the controlling authorities. They check extra during and after high water and storms. This mainly happens by means of visual inspections.

Parameters and aspects that may be important for inspection of the asphalt coverage are summarized in Table G.5.

TABLE G.5 INSPECTION PARAMETERS FOR ASPHALT COVERAGE AND RELATED ASPECTS

Inspection parameter	Significant unit	Accuracy	Inspection frequency	Spatial distribution	Explanation
Thickness	cm	Unknown	Varying, from daily to every few months	Point measurements. Distributed randomly	The thickness determines the strength of the asphalt layer. The point measurements are distributed across the covering. There is not regular distribution for the number of point measurements.
Development of cracks and fraying	Depth, length and width of the crack: in cm	Unknown	Varying, from every few months to annually	All cracks and frays	Cracks and frays may cause erosion and holes underneath the asphalt. These holes quickly become apparent because the asphalt will also subside. Plant growth may develop in cracks.
Holes underneath the covering	cm	Unknown	Varying, every few months to annually. After high water.	Covering the area	Hollow spaces cause the asphalt to subside and to develop cracks. Holes usually become apparent quickly because the asphalt also subsides. Requirement: observation from a depth of 2 cm.
Stripping (crumbling of the top layer. Thickness becomes thinner)	cm	Unknown	Usually every five years	Covering the area	The process that the top layer of the asphalt comes loose.
Rigidity	In accordance with laboratory measurements	In accordance with laboratory measurements	Usually every five years within the framework of LTV.	Point measurements. Distributed randomly	The rigidity states the extent to which the asphalt can absorb being hit by waves. The point measurements are distributed across the covering. There is not regular distribution for the number of point measurements.

## G.7 EMBANKMENT

In order to determine the strength of the flood defense system, the following qualities are important:

- Embankment structure of the dike (in great detail);
- Structure of the shallow and deep subsoil underneath the flood defense system and in the surroundings;
- Structure of the foreshore;
- Presence of the non-flood defense system in, on, at and near the flood defense system (cables, pipelines, buildings, etc.).

The structure of the dike will hardly change across time, or not at all, but will mainly become more compact. Activities of outsiders may lead to disruptions and changes in the structure of the flood defense system. This may include (illegal) digging in the dike in order to, for instance, laying cables, pipelines or basements.

The control efforts are mainly aimed at documenting data and making them accessible, also in the long term, regarding the dike and subsoil, cables, pipelines and other non-flood defense system elements. No detailed data are usually available of older dikes, regarding their structure of composition.



## G.8 GROUNDWATER/SURFACE TENSION

The water present in a flood defense embankment greatly influences the strength and stability of the flood defense system and therefore is an important parameter on which the controlling authority focuses much attention. The following things are important:

- The location of the phreatic surface in the dike and changes therein;
- Surface tension/rise levels and subsoil and changes therein.  
Mainly at the location of layer changes;
- Groundwater flows through the various soil layers and changes therein;
- Soil fluids (capillary and funicular zone above the phreatic surface) and changes therein.

As opposed to the static soil structure of the flood defense system, fluid contents and surface tensions in the soil in and around the flood defense systems are often subject to change. This applies less so to regional flood defense systems. In general, the groundwater level in basin quays, for instance, does not change that quickly due to the little changing preconditions. After all, the basin level does not fluctuate much. However, in combination with extremely long rainfall or drought, critical situations may arise as a result of the changing water condition or surface tensions.

In the case of river dikes, the open water level may rise and decrease relatively quickly in relation to the groundwater.

Sea dikes and lake dikes often deal with short periods of high water. Elements such as the average inland and open water levels, waves, wave action may influence the groundwater condition.

Parameters and aspects that may be important for inspection of the groundwater are summarized in Table G.6.

**TABLE G.6 INSPECTION PARAMETERS FOR GROUNDWATER**

Inspection parameter	Significant unit	Accuracy	Inspection frequency	Spatial distribution	Explanation
Water content (peat dikes)	Water content (%)	(%)	Varying, from daily to every month	Point measurement	Only if needed, for instance, in the case of extreme drought
Groundwater level in the dike	m comp. NAP	5 cm	Varying, from daily to every month	Point measurement	In the case of varying and extremely high river water levels at least daily in connection with possible softening
Rise level of 1st aquifer package	m comp. NAP	10 cm	Varying, from daily to every month	Point measurement	<i>In the case of varying and extremely high river water levels at least daily in connection with possible flooding</i>