Ministry of Transport, Public Works and Water Management

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Management and maintenance of hydraulic infrastructure – Dutch experiences

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Preface

This report **Management and maintenance of hydraulic infrastructure – Dutch experiences** has been prepared for the refresher course for alumni of IHE in Bangladesh. The goal of the refresher course is to :
Familiarise participants with new insights and focal points in integrated water resources management and the delivery of services, which are at the very purpose of water management.
One of the points to which special attention is paid to is oparation and maintenance of infrastructure.

The report gives an overview of management and maintenance principles which the Dutch Ministry of Transport, Public Works and Water Management applies to the national hydraulic infrastructure. Therefore, the report is very much a framework.

Some examples or specific situations are described in more detailed fashion in so-called boxes or separate appendices. Especially the appendices contain detailed information on management of flood defences, coastline, rivers and water systems. Most of these appendices are included in this report. However some appendices were available as a separate publication and have been added to this report as course material.

The authors have tried to give an overview of Dutch principles and experiences without trying to transfer this information to the situation in Bangladesh. That is the enormous task which lies ahead for the technicians, engineers, policy makers and politicians in Bangladesh. We hope that the framework, the examples and the discussions during the refresher course may contribute to this.

Richard Jorissen and Rien van Zetten

1 Introduction

For a low lying country like The Netherlands management and maintenance of the water systems and associated infrastructure is essential from various viewpoints :

- Safety : the discharge and storage of water combined with the system of primary flood protection structures (dunes, dikes, barriers) provide an adequate protection against flooding, both coastal and fluvial.
- Transport : the safe and efficient transport of people and goods using inland and coastal waterways.
- Water quality and Ecology : clean water en healthy water systems, both for natural purposes and use by man.

Figure 1.1
The Netherlands

Integral water management is aimed at serving all purposes mentioned above. Water management in The Netherlands is the implementation of water (related) policies by means of infrastructure (´ hard´ measures) and legal measures (´ soft´ measures). These measures are developed and implemented within the natural and financial restraints to reach an optimal solution for living, working and recreation.

On a national level various water related policies haven been developed. Most of these policies are related to a specific item or aspect of water management :

- Water quality;
- Water quantity;
- Flood protection;
- Shipping and transport;

- Ecological quality of water systems;
- Coastal management;
- Fishing;
- Drinking water supply;
- Sand and gravel mining.

For most of these items or aspects the policy is described in the Fourth National Water Policy Document **[Appendix 1] and the third Coastal Policy Document** [Appendix 2].

The national water management plan is aimed at implementing these policies or at least an ´ optimal mix´ . However, the national water management plan is still too general and limited to the national authority, the Ministry of Transport, Public Works and Water Management. Therefore regional water management plans form the basis for actual management and maintenance. The circle is closed by evaluating the costs and benefits of the policies. Based on this evaluation the cycle begins again by formulating (new) policy goals. Figure 1.2 shows the relation between national policies, management plans and evaluation.

Figure 1.2
From policy to management

2 Scope of management and maintenance

2.1 Themes

The scope of management and maintenance is aimed at the main themes: safety, transport and ecology. In more detail these themes represent :

- Safety :
  - ⇒ Maintaining legally prescribed safety
  - ⇒ Preventing coastal erosion
  - ⇒ Space for the rivers
- Transport :
  - ⇒ Maintaining and developing transport routes
  - ⇒ Maintaining and developing recreation routes
- Ecology :
  - ⇒ Clean water and water systems (including riverbeds)
  - ⇒ Restoring natural conditions in rivers, lakes, deltas and coastal areas

The theme ´ ecology´ supports many functions of water systems, such as water quality, ecology, drinking water, cooling water, fishing (both commercial and recreation) and swimming.

2.2 National water systems

The themes safety, transport and ecology are the basis for management and maintenance of the national water systems :

- the main rivers Rhine, Meuse and Scheldt;
- the main canals;
- the North Sea;
- the (southern) Delta;
- the Wadden Sea;
- Lake IJssel.

The Ministry of Transport, Public Works and Water Management manages lakes, tidal waters and about 850 kilometres of rivers. The total length of national canals is approximately 300 kilometres. The dikes around the large central Lake IJssel are approximately 110 kilometres long. See figure 2.1

The national water system features 10 weirs, 9 discharge sluices and 7 pumping stations for water quantity management, see figuur 2.2.

For flood protection purposes there are 2 storm surge barriers and 2 locks. For shipping there are 50 shipping locks; most of these locks are also used for water quantity management, see figure 2.2.

The Netherlands is protected against flooding by nearly 3000 kilometres of primary flood defences, of which only 300 kilometres is managed by the regional directorates of the ministry. The other defences are managed by water boards, see figure 2.3 and section 3.2.
The Dutch Water Boards can be compared with the Bangladesh Water Management Assiciations.

Figure 2.1
National water systems

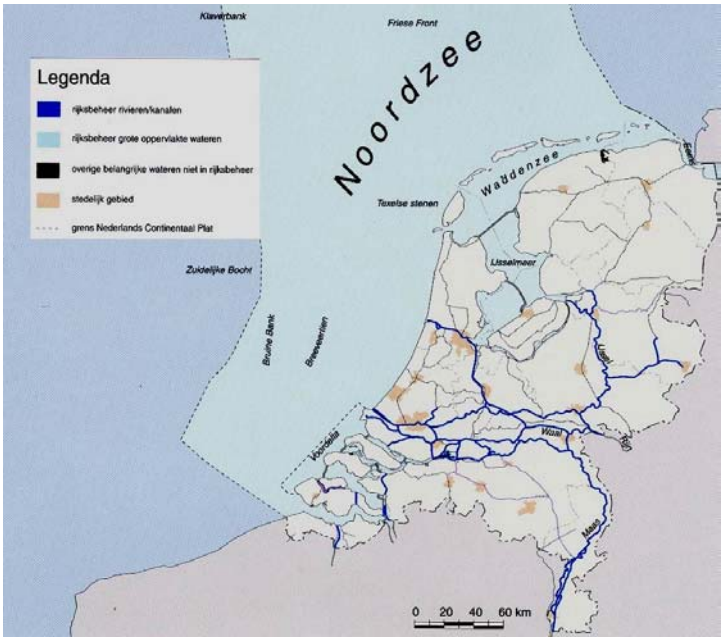


Figure 2.2Water quantitymanagement

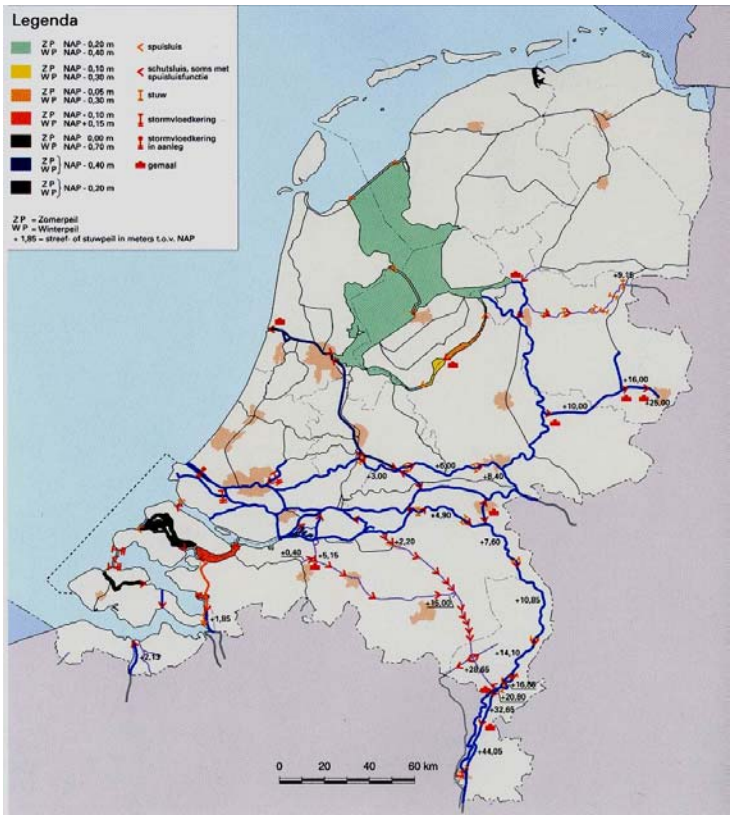
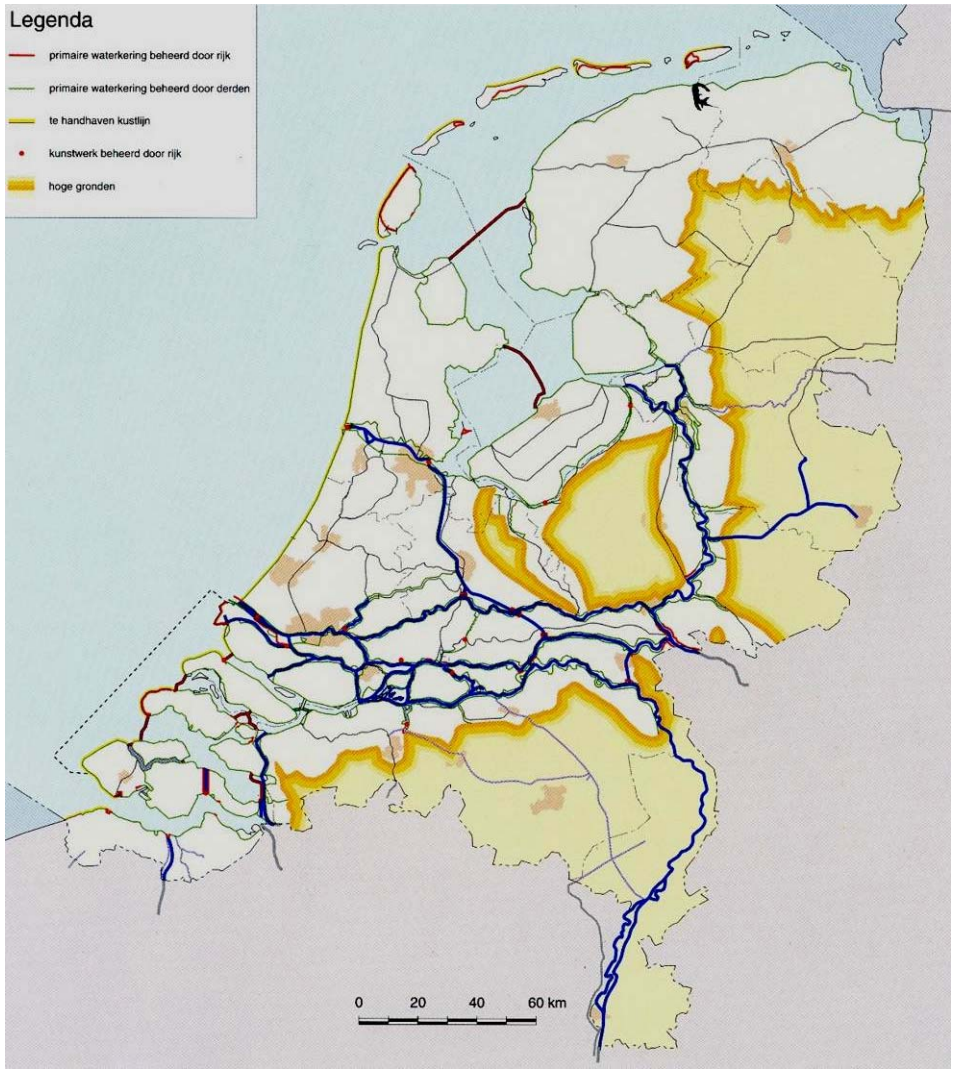


Figure 2.3
Flood defences



2.3 National water management plan

The national water management plan shows how the Ministry of Transport, Public Works and Water Management (on behalf of the national government) realises the policy goals. This plan has a horizon of 4 years (2001-2004). For all water systems the plan describes :

- the actual management and maintenance situation;
- the functions assigned to the water system;
- the reference situation;
- stepping stones to reach the reference situation;
- measures to realise the stepping stones;
- the required budget
- long term perspectives (beyond 2010).

Because of the ambitious scope and the diversity of the water systems the national water management plan is restricted to a global programme. This global programme

is further elaborated by the regional directorates of the Ministry of Transport, Public Works and Water Management.

The national water management plan is also a reference for regional authorities involved in water management. Although this contribution focuses on the national infrastructure, regional infrastructure and water systems are just as vital as their national pendants. The role of provinces, water boards and local communities is essential to reach policy goals. These authorities make their own management plans based upon the national management plan.

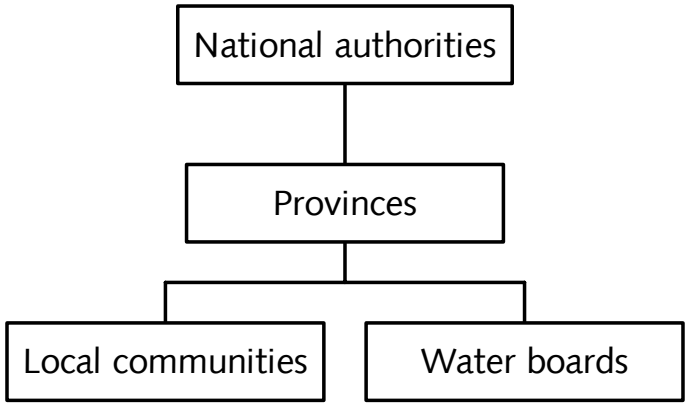
Although the national water management plan doesn't have a legal status it is a very important document because it forms the link from policy to practice. In the process of preparing the plan all authorities and individuals are able to respond to an official concept of the plan. Only after this hearing phase the plan is made final.

3 Organisation

3.1 General description

The Netherlands is a decentralised state. National, regional and local authorities operate both together and independently.

Figure 3.1
Authorities on three levels



The ministries are the national authorities. Most of these national authorities were formed 'only' 200 years ago during the French occupation of The Netherlands by Napoleon. The ministries are responsible for policy making, managing processes and infrastructures of national interest. Each ministry is headed by a minister (in some cases assisted by a deputy minister) and the parliament is supervising the (deputy) minister. The members of parliament are elected directly. The ministries are organised thematically :

- Internal affairs
- Foreign affairs
- Defence
- Economic affairs
- Agriculture, Fisheries and Nature conservation
- Spatial planning
- Social affairs
- Health affairs
- Transport, Public Works and Water Management.

The provinces are regional authorities and have a great history. The so-called Golden Age of the Netherland (16th century) was the age of the seven provinces which together were the predecessors of The Netherlands. In the present the provinces are mainly responsible for :

- Integrating national policies in regional spatial planning;
- Supervising local authorities.

The provincial authorities are lead by so-called deputies and controlled by at regional parliament, which is elected indirectly. The chairman of the board of deputies is appointed by the minister of Internal affairs.

There are two types of local authorities : local communities and water boards.

Local communities is the general democracy at a local level. The citizens of a community elect their representatives (one man one vote), which in their turn elect the 'wethouders'. The mayor is appointed by the minister of Internal affairs.

Water boards is a form a specific democracy on a local level. Their tasks are limited to water management (quantity, quality, flood protection) only and they are only allowed to raise taxes for these purposes. Already in the 12th century there were water boards in The Netherlands (no national, regional or other , local authority did exist at that time). Again the inhabitants elect their representatives (according to their degree of interest), which in their turn elect the 'heemraden'. The dike reeve is chairing the board of 'heemraden' and is appointed by the minister of Internal Affairs.

3.2 Decentralising water management

The general description is also valid for the situation in water management. The relation between the various authorities is often historically determined. In fact, the water boards are the oldest public authority in our country, dating from the early Middle Ages.

In 1991 the relation between national and regional authorities was clarified, which led to the following role for the ministry. This role is considered to be essential for the national authority.

The national authority (Ministry of Transport, Public Works and Water Management) is responsible for :

- infrastructure for transport (from construction to utilisation);
- flood protection, water quantity and water quality.

The ministry actually manages a water system and associated infrastructure if :

- the scale of the water system is larger than the provincial scale;
- a regional authority can't bear the risk associated with the management responsibility.

In other cases the water system can be managed by a province or local community (for shipping routes) or a water board (water quantity and water quality).

The ministry actually manages a flood defence if :

- a regional authority (water board) can't provide the required budget for management and maintenance;
- the scale of the (impact of the) flood defence exceed the scale of the regional authorities involved.

In all other cases a water board will manage the flood defences. The required budget for management and maintenance is raised by local taxation.

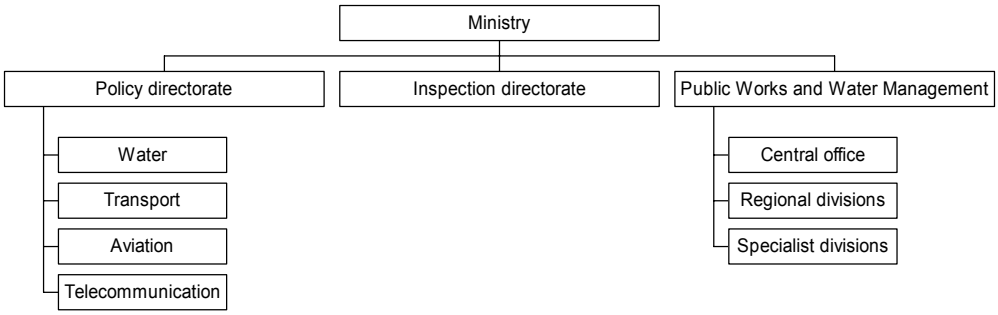
The coastline is managed by the ministry because the scale of this ´ object´ is larger than the regional scale of the water boards.

3.3 Organisation of the ministry

The Ministry of Transport, Public Works and Water Management consists of three main directorates :

- Policy directorates;
- Inspection directorate;
- Public Works and Water Management directorate.

Figure 3.2
The ministry



The policy directorate is responsible for the total cycle of policy, implementation and evaluation.

The inspection directorate is an independent directorate within the ministry, responsible for the inspection and monitoring of vital processes, such as issuing of various permits and maintaining standards.

The directorate of Public Works and Water Management is responsible for the implementation of policies.

The regional divisions are responsible for the management and maintenance of water systems, flood defences and the coastline.

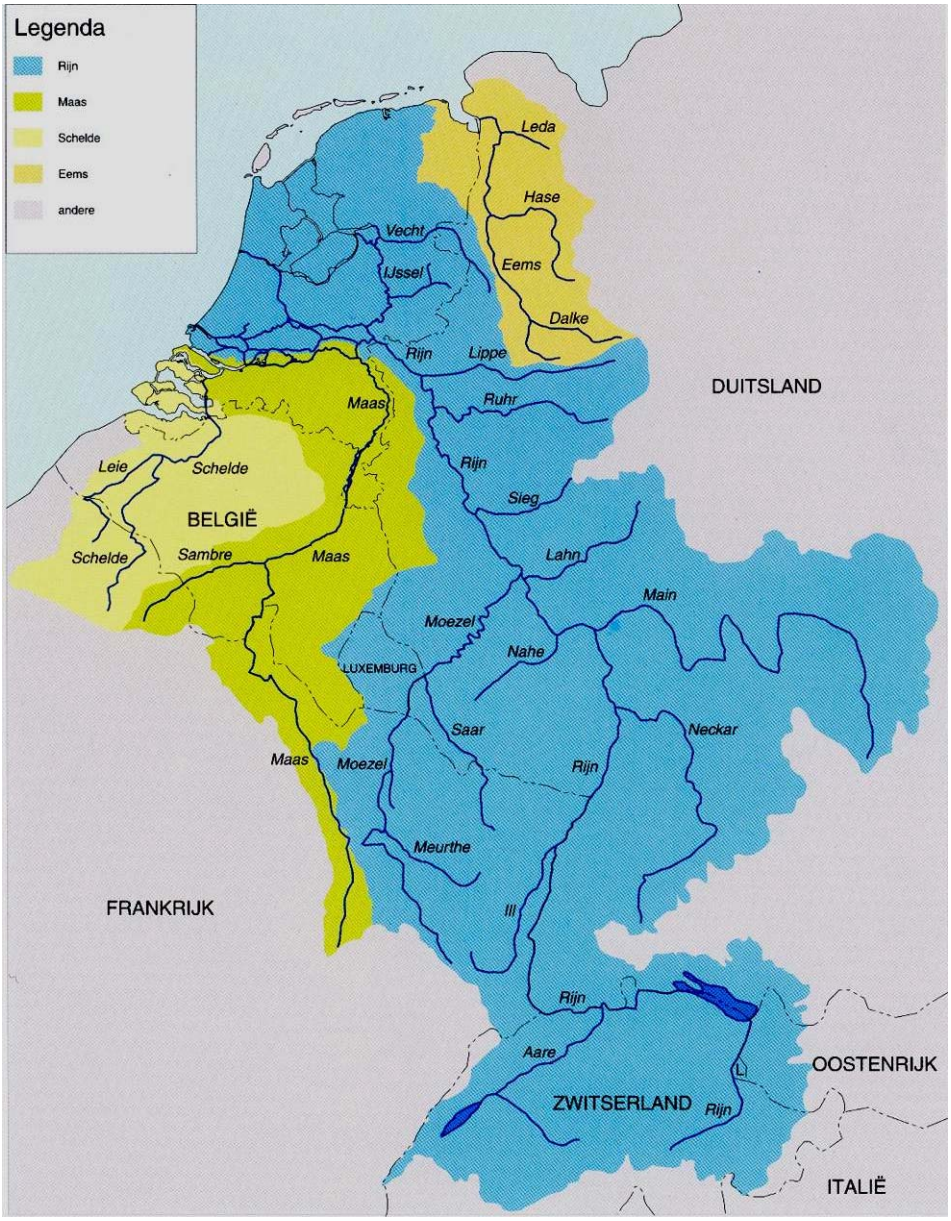
The specialist divisions are responsible for monitoring, research en advice, supporting the regional divisions, the inspection and the policy directorates. The National Institute for Coastal and Marine Management / RIKZ is one of these specialist divisions.

The central offices coordinates the activities of both regional and specialist divisions.

4 International aspects

The Netherlands is situated in the delta of four main European rivers. The total catchment areas of these rivers cover a large part of north western Europe and include nine countries.

Figure 4.1
International context



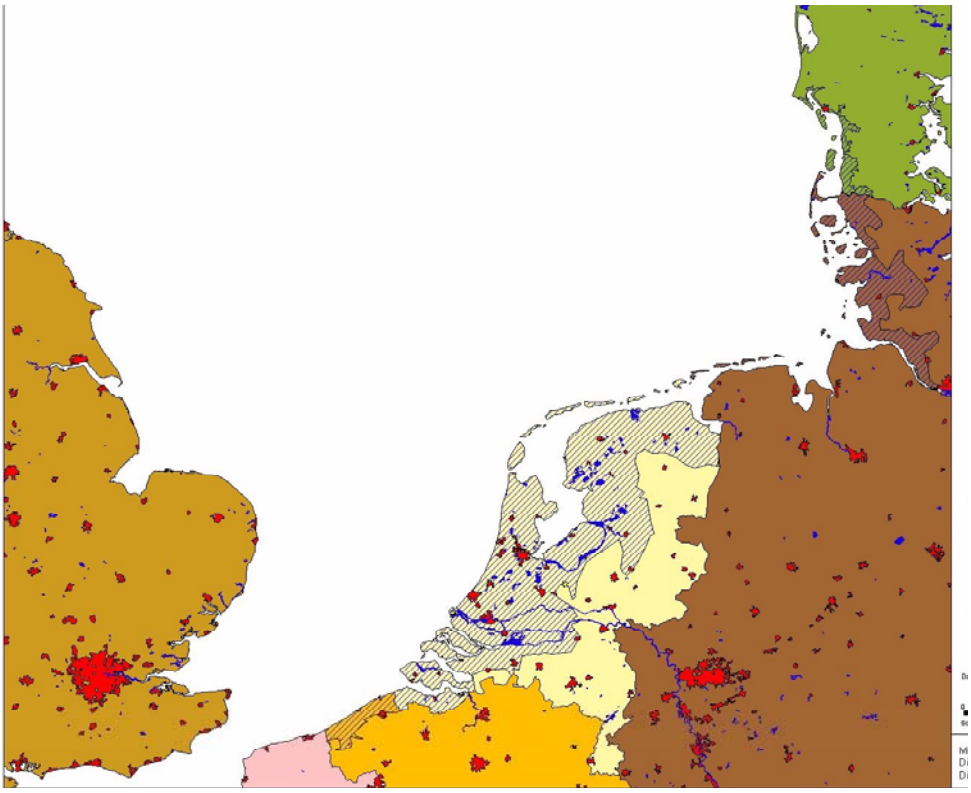
Also the Wadden Sea, North Sea and the north eastern area of the Atlantic together form an interlinked water system. International co-operation is essential for a sustainable management of these water systems.

There is a large number of international forums which allow the exchange of information. These forums vary between bilateral agreements with neighbouring countries and regional forums such as international river and sea commissions. An increasing number of forums has the authority to make binding agreements such as

creasing number of forums has the authority to make binding agreements such as treaties and conventions.

For The Netherlands and other European countries the European Union is developing into an international authority, also with regard to water management. The European Union has issued a Guideline for Water Management for all water systems in Europe. This guideline has a similar structure as the national water management plan.

An interesting example of international exchange of information leading to a better understanding of different situations in five countries bordering the North Sea is a comparative study of the aspect of flood protection in Belgium, the United Kingdom, Germany, Denmark and the Netherlands **[Appendix 3]**.



Flood prone areas around the North Sea

The scope of this report is aimed at technical, legal, organisational and historical aspects. The report shows that the scale of the potential flooding disaster and the organisation structure in a country are the determining factors in organising flood protection management.

5 Objectives of management and maintenance

5.1 Integral and functional water management

The Netherlands form an important part of the catchments of four main European rivers : Rhine, Meuse, Scheldt and Ems. The Dutch water systems are a mixture of natural systems (rivers and sea) and human interventions (canalisation, locks, dikes, barriers). About 70% of the land surface needs protection against flooding. An extensive system of primary flood defences provide an excellent standard of protection against flooding from the rivers and sea. But there is more, water systems provide other and essential functions, like :

- transport;
- surface water and groundwater for agriculture and industry;
- ecological values;
- recreational use;
- drinking water supply.

Preventing pollution is very much associated with most of these functions. The policy of preventing pollution has been very successful. Now much effort is aimed at restoring the quality of the bottom of rivers, lakes and canals. Polluted sediment is being dredged and depending on the degree of pollution isolated or – after sanitation – re-used.

The Dutch have a tradition of dealing with water. But dewatering low lying areas for agriculture however has serious negative effects due to the settlement of soil (due to lowering of the groundwater table). The effect of (increased) sea level rise has to be added to this. It has become clear to us that we need a more adaptive strategy to accommodate the rising waters in stead of to combat this threat. The main policy goal is therefore :

To have and to hold a safe and habitable country and to maintain and develop resilient water systems which allow a sustainable use

Integral water management is our key to accomplish this audacious goal. By managing the water system (water, bottom and banks) as a whole based on assigned functions the Ministry of Transport, Public Works and Water Management focuses on realising reference situations in the national water systems. With regional and international partners agreements are made to reach a similar approach for entire catchment areas.

In a functional approach the first step is to assign one or more functions to a water system. The number of possible functions can be very large. In The Netherlands we have chosen for 13 functions, see table 5.1. The most common or primary functions are printed bold. The national management plan includes a detailed list of assigned function for each water system.

Functions		
Flood protection	Fishing	Hydropower
Discharge of water, ice and sediment	Bank recreation	Drinking Water
Transport	Recreational fishing	Commercial fishing
Water quality and ecology	Cooling water	Sand and gravel mining
Recreation		

Table 5.1 : Functions of water systems

A water system is functionallly adequate if the reference situation for each assigned function has been reached. The reference situation is the best possible condition for a water system, given the total number of functions of that water system.

Most reference situations for the primary functions have been reached already or will so in short notice. Flood protection, discharge and transport are more or less in order. The reference situation for water quality will be reached after 2020 (especially due to the poor quality of much sediment now lying on the bottom). For ecology the reference situation will be reached even later, in 2035. These differences are largely due to the prioritisation of the available funds for management and maintenance. This prioritisation is based on the number and type of functions which are to be fulfilled in a water system. Flood protection and transport are the so-called high priority functions.

The national management plan describes management goals for each policy goals. To provide a link between policy and regional management plans these management goals are described for six themes, see table 5.2.

Policy goals	**Management goals**	**Main functions**
Safety	Maintaining safety of primary flood defences	Flood protection / Discharge
	Preventing coastal erosion	Flood protection
	Increasing space for the rivers	Discharge in combination with flood protection, water quality and ecology
Transport	Maintaining and developing transport and recreation routes	Transport
Water quality and ecology	Providing clean water and water systems (including riverbeds)	All functions, with emphasis on water quality, ecology, drinking, swimming and cooling water
	Restoring natural conditions in rivers, lakes, deltas and coastal areas	All functions, with emphasis on water quality, ecology, drinking, swimming and cooling water
	Open eye for other functions	-
	Actual knowledge of water systems	-
	Decentralising management	-

Table 5.2 : From policy to management goals and functions

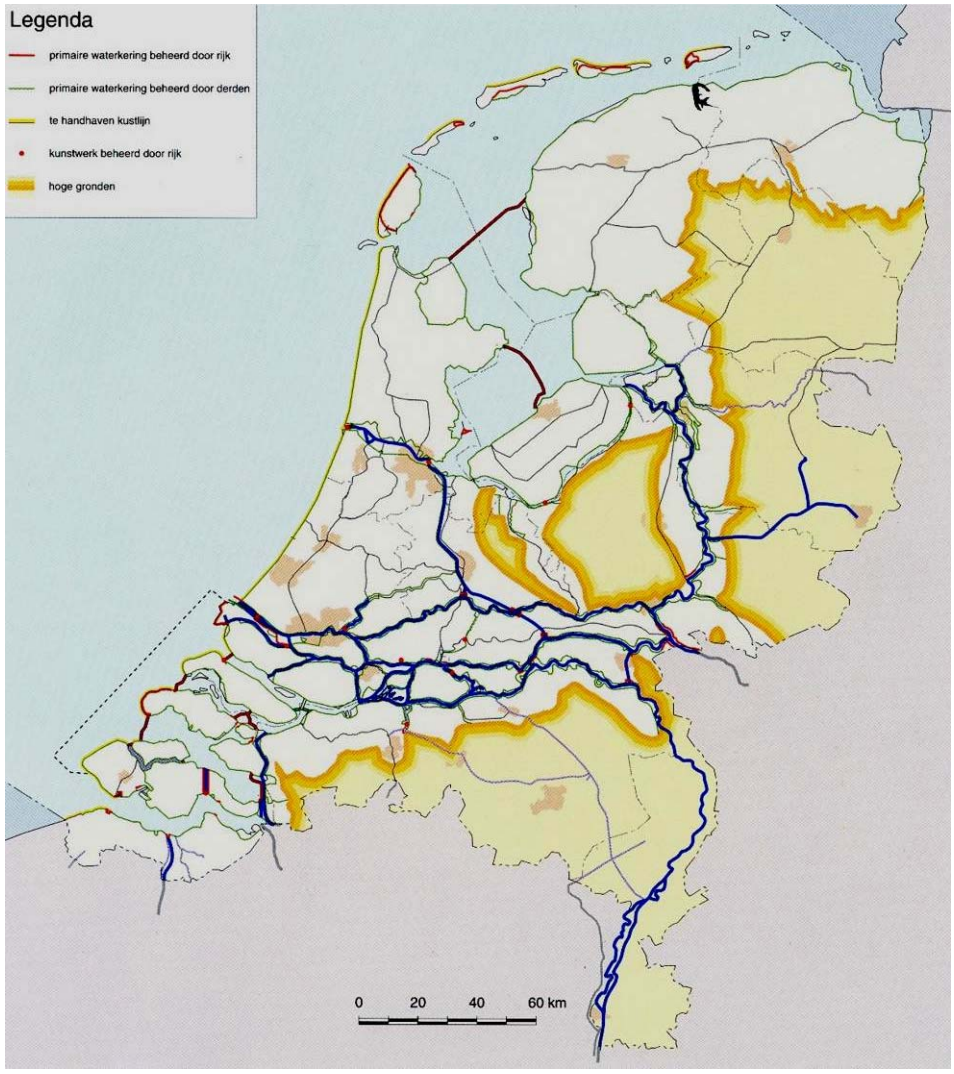
In addition to the six themes three ´ supporting´ themes have been defined. These themes have a more general and supporting character, but had to be fitted into the structure because (national and regional) management plans are the basis for nearly all funding within the Ministry of Transport, Public Works and Water Management.

In the national management plan the reference situation for each theme is described and specific actions and goals are formulated to reach this reference situation. For each theme the reference situation is given here. If relevant, specific information is added.

5.2 Maintaining safety of primary flood defences

Reference situation : All primary flood defence meet the legally prescribed safety standard. More information can be found in the included papers ´ Safety, risk and flood protection policy´ and ´ Assessment of safety against flooding in The Netherlands´ **[Appendix 4,5]**.

Figure 5.1
Flood defences



5.3 Preventing coastal erosion

Reference situation : The coastline is maintained at its 1990 position. The coastline provides a flexible (resilient) and natural flood defence. More information can be found in the included paper ´ Coastline management´ **[Appendix 6]**.

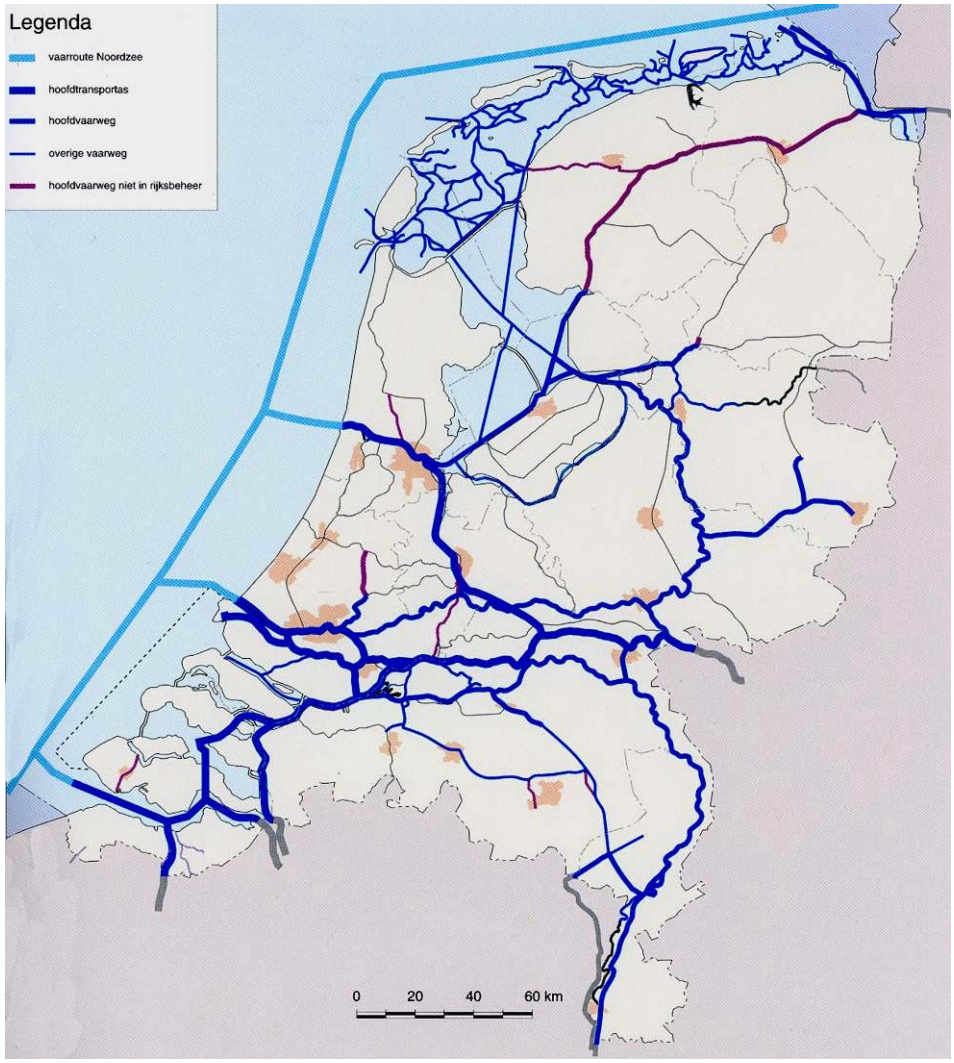
5.4 Increasing space for the rivers

Reference situation : The discharge of the main rivers is distributed in such a way that flood protection is served and shipping is possible under most conditions. This will be realised in combination with restoration of natural conditions in rivers. More information can be found in the included paper ´ ???´ **[Appendix 7]**.

5.5 Maintaining and developing transport and recreation routes

Reference situation : Inland shipping is developed optimally and shipping routes are optimally utilised. This global reference is described in more detail in the national management plan with specific goals for (physical) capacity of shipping routes, safety and management of the transport infrastructure like locks.

Figure 5.2
Transport routes



5.6 Providing clean water and water systems

Reference situation : The quality of water and sediment meets the national en international (European Union) standards. Dumping of hazardous substances is stopped in 2020. The quality of water and sediment doesn't interfere with a sustainable use of the water systems. Dredged sediment can be used or dumped without any limitations.

5.7 Restoring natural conditions

Reference situation : The dynamic behaviour of water systems is used and natural resilience is enhanced in order to guarantee a sustainable use. Natural processes play a significant role : erosion, sedimentation, tidal effect and gradients are essential to reach this reference situation. There is sufficient space for gradients between water and land, fresh and saline water. The relation between ecology and other functions (recreation and discharge)

5.8 Open eye for other functions

Integral water management requires specific measures for specific problems and/or situations. Combining measures may lead to optimal solutions. Although the Ministry of Transport, Public Works and Water Management has prioritised the key functions ´ Flood protection´ , ´ Discharge´ and ´ Transport´ the other functions can very well be served by co-operation between the ministry and other partners.

The national water management plan contains a number guidelines for the regional directorates of the Ministry of Transport, Public Works and Water Management how to combine other functions with the key functions.

5.9 Actual knowledge of water systems

Knowledge of the water systems is essential for management and maintenance. Monitoring and research support policy, management and maintenance.

The national water management plan contains a number of specific activities like monitoring and research. So-called specialist directorates of the Ministry of Transport, Public Works and Water Management are responsible for these tasks.

5.10 Decentralising management

In 1991 it was decided that a part of the national infrastructure could very well be managed by regional authorities, given the earlier described essential role of the national authority. This decision led to a list of 311 object which could be turned over to regional authorities.

The national water management plan describes the transfer of infrastructure objects from the national authority to regional authorities. The receiving regional authorities also receive a specific budget for future maintenance of these objects.

6 Management and maintenance in practice

6.1 Regional water management plans

The regional directorates of the Ministry of Transport, Public Works and Water Management prepare regional water management plans according to a specific and uniform structure. This structure allows prioritisation between the management plans of the various regions. The structure of regional water management plans is similar to the national water management plan (see section 2.3), but the information is much more detailed. The paper : Towards a functional infrastructure management for the 21st century **[Appendix 8]** give more detailed information on the regional water management plans.

Although regional water management plans are restricted to the national infrastructure, there is much interaction between the national infrastructure and regional infrastructure. National water systems like rivers receive water quantities from regional water systems like brooks and polders. On the other hand national water systems may act as an reservoir for polders. The regional directorates of the ministry and regional authorities have agreements on this. These agreements are laid down in the water management plans of both regional directorates of the ministry and regional authorities.

The primary flood defences are largely managed by regional authorities, the water boards. The water boards prepare flood defence management plans with a similar structure as the regional water management plans, although the scope of the flood defence management plans is limited to flood protection only.

6.2 Construction versus management and maintenance

Functional management requires a transparent relation between policy goals (outcome), management goals (output) and functions. For each function a reference situation is defined with specific quality standards. If the actual situation doesn't meet these standards improvement of the functional quality is necessary. This requires measures like construction ('hard' measures) or new regulations or operating procedures of existing infrastructure ('soft' measures). The measures are paid for using the so-called construction budget.

If the actual situation does meet the quality standards, maintenance of the functional quality is necessary. Again this requires measures, which are being paid for using the so-called maintenance budget.

6.3 Priorities

Distributing the available budget requires prioritisation. This process is always difficult, but is absolutely necessary to keep the pressure on items like cost awareness and cost effectiveness. In The Netherlands prioritisation is being done from three different viewpoints :

- political agreements (priority 1);
- priority based on functions :
  1. flood protection and discharge of water, sediment and ice
  2. transport using national water systems
  3. water quality and ecology
  4. transport using regional water systems
  5. other functions
- priority based on type of measures :
  - fixed maintenance before variable maintenance
  - project under construction before new tenders

A part of the available budget has been earmarked by the Parliament for specific projects. These projects are so-called politically labelled projects. Examples of these projects are :

- removing polluted sediments from river beds;
- restoring ecological quality along rivers and lakes;
- improving river and coastal dikes,
- decentralisation of management.

For these projects or programmes a fixed yearly budget has been identified.

The prioritisation based on function has a rather simple background :

- safety is essential : flood defences and a proper discharge of water, sediment and ice are vital to provide safety.
- transport is a economical important activity and especially the use of national water systems contributes significantly to the gross national product.
- the quality of water, bottom and banks of water systems is important and contributes to all other functions.
- the remaining functions (such as recreation, hydropower) must be served by having an open eye for synergy. Essentially this means that it is very unlikely that the ministry will implement a project or scheme serving only these remaining functions.

The prioritisation based on type of measures is probably even more down to earth. The difference between fixed and variable maintenance will be described in section 7.3.

6.4 Budget

The available national budget for water management in The Netherlands is approximately 1 billion euros (1 € is approximately 0,9 US$). To put this amount in a wider perspective :

- The gross national product of The Netherlands is approximately 400 billion euros
- The total budget of the national government is approximately 300 billion euros
- The total value land, infrastructure and goods in the flood prone areas of the Netherlands is about 2000 billion euros.
- The total budget of the ministry of Transport, Public Works and Water Management is about 7 billion euros.

Table 6.1 shows the present distribution of the available national budget (in 1000€).

Flood protection and discharge	Construction	300	300	300	300	300
	Maintenance	150	150	150	150	150
Water management and transport	Construction	160	160	160	160	160
	Maintenance	360	360	360	360	360
	Operating	50	50	50	50	50
	Monitoring	40	40	40	40	40
Total		**1060**	**1060**	**1060**	**1060**	**1060**

Table 6.1 : Distribution of budget

This budget is used to improve and maintain the functional quality of the national water systems. Nearly 40% is being spent on flood protection and discharge of water, sediment and ice. Transport receives also 40% and 15% of the budget is spent on improving water quality and ecology. Only 5% is spent on remaining functions, mainly as additional budget to allow these remaining function to profit from the

high priority functions. An example of this is the construction of bank recreation areas in combination with dike reinforcement.

By local taxation the water boards have their own budget for maintenance of 'their' primary flood defences. This amounts up to 400 million euros.

7 Optimising management and maintenance

7.1 General

Public spending needs a permanent attention for cost awareness and cost effectiveness. Within the Ministry of Transport, Public Works and Water Management this attention is focused on :

- the objects and infrastructure which are actually managed by the ministry;
- the organisation of the ministry (especially the number of staff en internal processes);
- the type of measures taken.

In 1991 the package of objects and infrastructure actually managed by the ministry was investigated and since then a large number of management tasks is transferred to regional authorities.

For optimising the organisation of the ministry and the measures taken three main developments are relevant :

- service level agreement;
- life cycle cost management;
- maintenance strategies.

7.2 Service level agreements

To make the relation between policy goals and management goals more transparent service level agreement will be introduced. At a national level required service levels will be determined as a framework for the regional directorates of the ministry. Again uniformity and cost effectiveness are the most important considerations for this.

For the function 'Transport' service levels have already been decided on. An examples of such a service levels is the availability of the transport route (e.g. 99% of the year).

7.3 Life cycle cost management

At present budgets for construction and maintenance are considered to be separate. In practice, this doesn't always lead to optimal solutions from a life cycle perspective. In the near future integral costs of construction and maintenance for new objects and infrastructure will be considered before deciding on construction.

7.4 Maintenance strategies

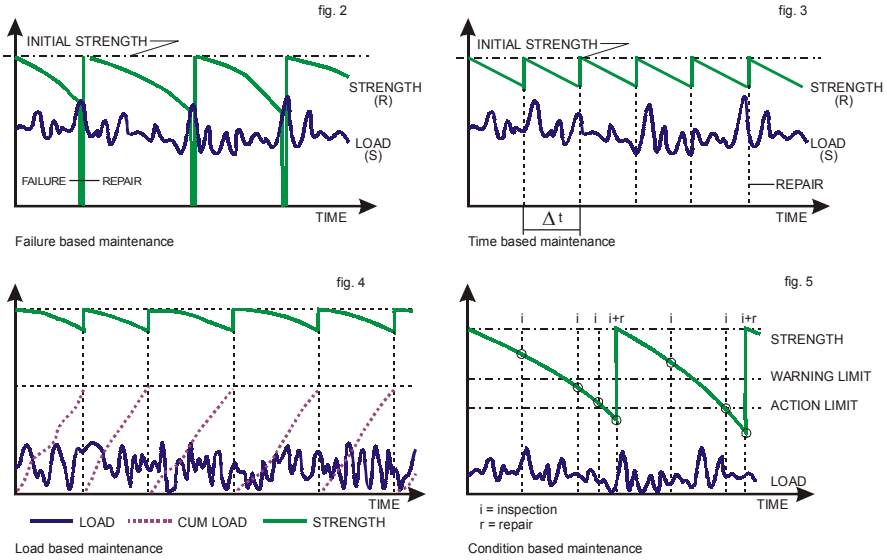
In general two main classes of maintenance strategies can be discerned : corrective and preventive maintenance. Corrective maintenance means that the object will be repaired after failure. This strategy is applied if the consequences of failure of the object are relatively small. In hydraulic engineering this strategy isn't applied very often because of the large consequences of failure. However, this assumption is not valid for all components of hydraulic infrastructure. Therefore, more and more components are maintained using the corrective maintenance strategy, which is in most cases extremely cost effective.

Several preventive maintenance schemes are available. The most advanced and generally the cost effective option is based on the actual condition of the object. However this requires a good description of the behaviour of the object (= deterioration model). Preventive maintenance requires always a form of inspection besides repair.

Costs of inspection have to be taken into account when deciding for a maintenance strategy.
Other options are time based and load based. Time based preventive maintenance is based on fixed intervals. These intervals may be based on experience or modelling. An intermediate form of preventive maintenance is load based. According to this strategy maintenance is done for example based on the number of passages of a shipping lock.

Research and monitoring is aimed at improving the deterioration models and inspection techniques in order to apply the conditions based preventive strategy as much as possible for the vital components of the object. If possible, corrective maintenance is preferred for the other components.

Figure 7.1
Maintenance strategies



These maintenance strategies are described further in the papers 'The maintenance of hydraulic structures' and 'Maintenance of hydraulic structures in The Netherlands : example storm surge barrier Eastern Scheldt **[Appendix 9, 10]**.

8 Monitoring and evaluation

The national water management plan doesn't yet provide a (yearly) evaluation of the actual management and maintenance. At present there is a number of evaluation activities :

- technical evaluations;
- evaluation of cost effectiveness of management and maintenance (output)
- evaluation of policy (outcome);
- specific evaluations.

Technical evaluations are quite common. Every year a joint commission of all water authorities issue a technical evaluation of the water management activities. This evaluation is limited to a description of the actual state of the water systems. The commission doesn't evaluate the effectiveness of management or policies.

The cost effectiveness of management and maintenance is stimulated by introducing service level agreements for all water systems. These agreements lead to a more uniform approach and effectiveness of our management efforts. Furthermore, life cycle cost management has been introduced to minimise life cycle cost. The costs of maintenance are already taken into account during the pre-construction phase of the project. A measure for the cost effectiveness of management and maintenance is the output, which for example stands for the volume of dredged material for a certain budget.

Effectiveness of policy is measured in terms of result for citizens, companies and other authorities using or depending on the national water systems. In stead of the volume of dredged material the accessibility of a harbour or canal is an important measure. Such a measure is called 'outcome'. Evaluation in terms of outcome has only been started in 2001 and it will take a while before this type of evaluation will lead to results.

A fourth type of evaluation is enforced by legislation. A good example of such a evaluation is the safety assessment of primary flood defences as described in **[Appendix 5]**. The managing authorities are obliged to report the actual safety of flood defences in a standardised way to supervising authorities, which in the end report to parliament.

9 Appendices (partially included)

The following appendices are partially included in this document. The appendices printed in *italics* are added separately.

[1] *Fourth National Water Policy Document, Ministry of Transport, Public Works and Water Management, 1998*

[2] *Tradition, trends and Tomorrow, The 3rd Coastal Policy Document, Ministry of Transport, Public Works and Water Management, 2001*

[3] *Flooding risk in coastal areas – Risk, safety levels and probabilistic technique in five countries along the North Sea Coast, R.E. Jorissen, J. Litjens-van Loon and A. Mendez Lorenzo, Ministry of Transport Public Works and Water Management, 2000*

[4] Safety, risk and flood protection policy, R.E. Jorissen, Ministry of Transport, Public Works and Water Management

[5] Assessment of safety against flooding in The Netherlands, A.P. de Looff and J.W. van der Meer, Ministry of Transport, Public Works and Water Management

[6] *Coastline management, Ministry of Transport, Public Works and Water Management, National Institute for Coastal and Marine Management / RIKZ*

[7] **Iets over ruimte voor de rivier !!!!!**

[8] **Towards a functional infrastructure management for the 21st century**

[9] The maintenance of hydraulic structures, J.K. Vrijling, H. Kuiper, R.E. Jorissen, H.E. Klatter, Ministry of Transport Public Works and Water Management

[10] Maintenance of hydraulic structures in The Netherlands, R.E. Jorissen, R.P. de Leeuw van Weenen, Ministry of Transport Public Works and Water Management

ASSESSMENT OF SAFETY AGAINST FLOODING IN THE NETHERLANDS

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1. INTRODUCTION

With the Flood Protection Act of 1996 (FPA) a new era in water defence management in the Netherlands has started. The purpose of this Act is to provide and to maintain long-term safety. Within a few years (2001) the program on extensive reinforcement of the sea- and river defence system will be compeeted, nearly half a century after the beginning of the works which were initiated by the 1953 flood. The central government wants to consolidate the safety level as achieved at the time of completion. The management of the flood defences is crucial for the long term maintenance of the safety achieved. For this reason managers are obfged (by FPA) to check the technical state of their flood defences every five years against the current safety specifications. This concept of how to ***maintain*** the achieved safety level of the water retaining structures is new in the Netherlands. To facilitate the safety assessment a technical guidefne was introduced. The main topic of this paper is the safety assessment in relation to the technical guideline and the impact on management and maintenance.

2. THE FLOOD PROTECTION ACT

The low-lying regions of the Netherlands are divided into 53 so-called "dike ring area's". Figure 1 gives a (fictive) example of a dike ring area, which consists of various types of water defence structures: dikes, sluices, locks, dunes, etc. The circle of linked water defences forms the protestion of the dike ring area against flooding. Each dike ring area has an acceptable level of risk (safety standard). These safety levels are laid down in the FPA and have to be maintained by the managing local administrations. The day-to-day management of flood defences is not primarily the responsibility of the central government, but of the 41 district water boards (local administrations). The Provinces perform a supervisory function, with the central govenment acting as chief supervisor.

The FPA gives rules for:

- the supervision of the local administration by the regional authority (Province),
- the supervisoryn of Provinces by the National Authority (Mnistry of Transport, Public Works and Water Management),
- the provision of (technical) guidelines for assessment, design and management,
- the contents of data-bank registers, to be set up by the local administration,
- the hydraulic boundary conditions to be used for safety assessment and design,
- the procedure to be followed by the local administration and by the Province for the justification reports,

THE MAINTENANCE OF HYDRAULIC STRUCTURES

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1.0 INTRODUCTION

With the completion of the Eastern Scheldt storm surge barrier the Delta plan was realized. Herewith a period of the construction of large hydraulic engineering structures ended more or less. Therefore the interest in the optimal maintenance of the existing structures is growing and efforts are made to develop a theoretical basis for the planning of maintenance.

In the field of mechanical engineering considerable progress has been made. Maintenance is defined as consisting of two activities inspection and repair. Inspection implies the observation of the state of the structure and repair the restoration of the structure to it's original state.

Two main classes of maintenance are discerned: corrective and preventive maintenance. In this classification only the last subclass contains inspection besides repair. When a corrective maintenance strategy is applied, the structure will be repaired after failure. In a preventive maintenance scheme the structure will be repaired at specified intervals defined in time or operational hours before failure occurs. In a more refined strategy the state of the structure is inspected at such intervals. On the basis of the inspection result the decision to repair is taken.

SAFETY, RISK AND FLOOD PROTECTION POLICY

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SUMMARY

The flood protection policy of the Netherlands is largely based on a risk concept, although this concept is not applied directly into practice. Following the disastrous floods of 1953 legally prescribed safety standards are indirectly related to potential damages. At the end of this century dikes, dunes and other water retaining structures in all parts of the country meet the prescribed safety standards. A regular safety assessment is foreseen as a key element of management and control of these structures. However, social and economic development of our country may change the perception and acceptance of flooding risks. The number of people protected by dikes and the economic value of the protected areas both increase and so does the flooding risk. In order to monitor this development and to contribute to an adapted flood protection policy the Ministry of Transport, Public Works and Water Management (the ministry) and the technical advisory committee on water retaining structures (TAW) are developing a flooding risk concept, which can be applied directly into practice.

1 INTRODUCTION

As a low lying and highly developed country the Netherlands are continuously facing a potential flooding disaster. Large parts of the country lie below water levels that may occur on the North -Sea, on the rivers Rhine and Meuse and on the IJsselmeer. In some places potential flooding dëpths range up to 8 metres. Flood protection measures have to provide sufficient safety to the large number of inhabitants and the ever increasing investments. Construction, management and maintenance of flood protection structures are essential conditions for the population and further development of the country.

Most of the Netherlands is protected by flood protection structures. Along the coast protection against flooding is principally provided by dunes. Where the dunes are absent or too narrow or where sea arms have been closed off, flood protection structures in the form of sea dikes or storm surge barriers have been constructed. Along the full length of the Rhine and along the lower parts of the Meuse river protection against flooding is provided by dikes. This adds up to a total of about 2500 kilometres of flood protection structures, which are vita] for the existence of our nation [11. In addition to this there is a much larger length of minor embankments, which in genera] have a local water management function.

History shows that flooding disasters nearly always resulted into actions to improve the situation by raising dikes or improving the discharge capacity of the rivers. The disastrous flood of 1953 marks the start of a national reinforcement of the flood protection structures. The near floods of 1993 and 1995 did accelerate the final stages of this reinforcement programme [21. History also shows that neglect is the overture for the next flooding disaster. In an attempt to improve on this historic experience the safety of the flood protection structures in the Netherlands wilt be assessed regularly. Maintaining the strength of the dikes at level according to the legally

Towards a functional infrastructure management for the 21 st century

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Keywords: functional infrastructure management, water management, maintenance, wet infrastructure, structural works

ABSTRACT: Over the last 5 years wet infrastructure management in the Netherlands has gone through a revolutionary development. In the quest for methods to improve the way account is given on how national policy is implemented, the Ministry of Transport, Public Works and Water Management initiated a process to change traditional technical wet infrastructure management into modern functional wet infrastructure management. In the traditional approach the programmes for management and maintenance ware mainly determined by expert opinions about the technical state of the infrastructure at the operational level. There was no direct link with national policy objectives, resulting in a lack of control regarding the implementation of wet infrastructure policy and the spanding of tax money. *Functional management* implicates management is based upon the *purpose the water system serves.* The functional approach helps the infrastructure manager to maintain the existing infrastructural objects within the scope of the functions it serves and to (re)construct objects when this is necessary according to functional policy objectives.

1 INTRODUCTION

The Netherlands are a small country in western Europe. It is a delta area used by a lot of different stakeholders which are interested in the abundant water resources, both surface and groundwater reservoirs. The Directorate-General for Public Works and Water Management (Rijkswaterstaat), as part of the Ministry of Transport, Public Works and Water Management, carries out the wet infrastructure and water management for the bigger, state water systems such as rivers, navigable canals, lakes (both fresh and tidal water), a strip of the North Sea and the Wadden Sea (shown in figurel).

This paper will elaborate on the principles of functional wet infrastructure management by the Directorate-General of Public Works and Water Management (Rijkswaterstaat). Management measures can be derived from policy objectives following a 10-steps system for functional wet infrastructure management. This system will be illustrated by elaborating the method for a wet infrastructural object in one of the water ways in the Netherlands: the Prinses Beatrixsluis. Basis for this management tooi is the water system approach, characterized by a holistic view on the structure and functioning of water bodies (ground and surface water) and their surroundings.

Finally, the implementation of a functional approach in management and the advantages and disadvantages of the method are being discussed.

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MAINTENANCE OF HYDRAULIC STRUCTURES IN THE NETHERLANDS : EXAMPLE STORM SURGE BARRIER EASTERN SCHELDT (*)

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R. P. de LEEUW VAN WEENEN

THE

1. INTRODUCTION

The construction of the Eastern Scheldt storm surge barrier completed the Delta plan and ended more or less a long period of the construction of large hydraulic engineering structures in the Netherlands. Because of their dimensions and consequently the cost of maintenance the interest in the optimal maintenance of existing hydraulic structures is growing and efforts are made to develop a theoretical basis for the planning of maintenance. In the field of mechanical engineering the use of such theoretically based models is relatively widespread compared to hydraulic engineering.

Maintenance is defined as consisting of two activities : inspection and repair. Inspection implies the observation of the state of the structure. Repair implies the restoration of the structure to its original state. This paper will describe an overview of maintenance strategies. An example is worked out to show how a selected strategy can be applied in practice.

2. MAINTENANCE STRATEGIES

In general, two main classes of maintenance are distinguished corrective and preventive maintenance. -Of these classes only the latter

(*) *Entretien des ouvrages hydrauliques aux Pays-Bas exemple du barrage anti-tempête de l'Escaut Oriental.*