Overview of the Dutch water management system

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ABSTRACT This paper contains a description of the characteristics and historical development of the Dutch water management system in both a technical and institutional sense. It identifies the main water management problems in the current situation and those anticipated in the future. It describes the developments in the field of institutional reorganization and legislation that have recently taken place and those to be expected in the future. The new legislation will require the preparation of water management plans for each of the 11 provinces in the Netherlands and for the nation as a whole. This creates a need for planning studies and appropriate analytical tools to help the national and regional water managers carry out this task. The paper gives an overview of the main planning studies and activities with respect to regional and national water management that were carried out in recent years and in this way provides an introduction to the topics of the remaining papers.

INTRODUCTION

For reasons that will hopefully become clear further on in this paper, the Netherlands have carried out a very substantive national policy analysis for their water management system, known by its acronym PAWN. At the same time, in-depth analyses have been executed comprising smaller parts of the country. In the near future, national and provincial water planning will have to develop. Interrelation and integration will have to be established between the larger- and the smaller-scale analysis methods and results.

In view of the knowledge and experience gained during these studies, it seemed appropriate to publish them and so make known as much as possible about them to the international professional community. Because of the many aspects that were covered, even a moderate choice of the most interesting parts of the studies could not be squeezed into one paper. For the Exeter symposium, six papers have been prepared, covering as much of the ground as was necessary to characterize the available material in an acceptable way.

The present paper, the first of the series, gives a brief description of the Dutch water system, of the present and anticipated problems related to it, and of some institutional and legislative background. The six papers should be regarded as one cohesive source of information, of which the subject matter and the rationale behind it can only be properly appreciated in relation to the subjects dealt with in this introductory paper. The papers on the subject matter...
are in sequence:

(a) *K.P.Blumenthal: Overview of the Dutch water management system;* description of the system, its historical background, the problem area, and modern structural and legislative developments that called for a study like PAWN.

(b) *M.A.Veen & G.Baarse: Policy analysis of water management for the Netherlands (PAWN);* general overview of the methods and results of PAWN.

(c) *E.van Beek: Approach of various competitive water users and impact categories in PAWN;* trade-offs among users and allocation of water regarding the categories agriculture, shipping, industries, water supply and power plants.

(d) *E.Romijn & M.Tamminga: Allocation of water resources in the eastern part of the Netherlands;* approach, components and results of analyses carried out in two provinces in the part of the country situated above high tide level.

(e) *G.Baarse & G.Miedema: Modelling approach for a regional water management study in a polder area;* tools and methodologies for areas below or around sea level, especially regarding salt intrusion at ship locks and by saline seepage.

(f) *M.A.Veen et al.: Water resources management: from policy analysis to policy formulation;* relation between results of analyses and policy formulation; recommendations for future approach to ensure usefulness of analyses.

The term "water management" will be used consistently throughout these papers. It is considered to include all the research, technical works and administrative measures, required to obtain the best possible effectiveness of control of the water occurring in the country or in a part of it, from a quantitative as well as from a qualitative point of view.

**HYDROLOGICAL AND INFRASTRUCTURAL CHARACTERISTICS**

The hydrological situation of the Netherlands is largely determined by the fact that almost the entire country lies in the estuarine area of three rivers: the Rhine, the Meuse and the Scheldt. From the map (Fig.1) it can be seen that the western and northern parts of the country lie lower than average high-tide level: from a more detailed map it might be seen that considerable areas are even below mean sea level, some parts more than 6 m.

These low lands are of Holocene origin, and rapid morphological changes have taken place until, roughly 2000 years ago, groups of humans were forced to settle here. They tried, vainly at first, but gradually with more success, to stabilize the situation. Very early, parts of the land were surrounded by dykes, first only to keep the storm tides out, later also to be able to maintain a desired water level by discharging surplus water through sluices: the first "polder".

The story of the fight against sea and river floods is one of successes and defeats. Many times, areas were flooded and reclaimed. The net result is that the level of the entire country, relative to mean sea level continued, and still continues, to go down. On the other hand, the protection against floods by dunes and dykes
The Dutch water management system continues to improve. The large water surface in the heart of the country was a small lake in the early Middle Ages; after the sea broke in, it became a huge, though shallow, estuary, the "Zuiderzee", fed by one of the Rhine branches, the River IJssel (10% of the Rhine flow). After a severe flood in 1916 the enclosing dam with discharge sluices was built (closing: 1932), creating the fresh water IJssel Lake of which large areas were reclaimed by constructing polders. The IJssel Lake now functions as a reservoir from which the northern part of the country can be supplied with fresh water; the lake also receives excess water from these areas.

Islands, surrounded by deep and dangerous estuaries, constitute the southwestern estuarine area of the country. Into these estuaries the Scheldt and the Meuse debouch, as well as 90% of the Rhine flow. Here, the fresh river water mixes with the salty tidal waters of the
Most of these estuaries have been or are being closed by huge dams, in the framework of the Delta Plan, following the disastrous flood of 1953. For the subject under consideration it is important to know (a) that the entrance route to Rotterdam harbour will not be closed and so remain open to tidal action and salt intrusion, and (b) that in the "Haringvliet" the dam contains very large discharge sluices. These sluices are utilized as an instrument to control the water level in the (now fresh water) northern Delta basin; thus the flow, and with it the salt intrusion in the Rotterdam waterway can, to a certain extent, be controlled.

The Delta Project, although of great importance as an engineering work has no other features of first-order water management interest. The Western Scheldt, being the entrance to Antwerp harbour, will also remain open; the Eastern Scheldt will remain open for environmental reasons but will have a storm surge barrier for safety reasons; and decisions on the creation of either salt or fresh water basins will be factors pertaining to the overall water balance of the Netherlands.

The Meuse River was canalized for inland shipping reasons. So was the Lower Rhine, but this canalization is also an instrument to control water flow. At low flows with the weirs partly or entirely closed, more water will flow down the IJssel to improve depth for navigation, and to enhance the supply of the IJssel Lake.

Amsterdam harbour lies at the eastern end of the North Sea Canal, the western end of which is separated from the sea by locks for sea-going ships. Operating these (and other) sea-locks constitutes an important source of salt intrusion into polder areas. Amsterdam is connected to the Rhine by the Amsterdam Rhine Canal, for which plans have been designed to make it suitable for substantial water transport in both directions, thus improving the flexibility of the system. A different way of enhancing flexibility is canalization of the river IJssel.

To give an impression of the complexity of the Dutch water system Fig.2 was added, showing the national and regional main systems in a stylized way, as utilized in a water management computer model. Secondary and tertiary systems are attached to this, and eventually the network branches into fine grids of "capillaries". Fig.3, illustrating the principle of a small polder, can be considered typical of these capillaries.

The low part of the country, and the river areas of the higher parts, are entirely made up of these polders. The general use is to control the water level by pumping water out into the storage canals ("boezems"), to be transported eventually to open water. In dry times, however, it may be necessary to let in water from the "boezem" canals. In normal periods, it is not too difficult to get rid of, or to supply, water.

In the "high" parts of the country, the means to transport surface water are often lacking. On the other hand, in contrast to the low polderlands, in these parts groundwater is fresh and of good quality, though often no longer abundantly available for abstraction. It should, in general, be noted that mentioning of "high" parts in the context of the Netherlands involves areas that are not entirely flat, and lie well above mean high tide.
THE PROBLEM

In very general terms the problem is to transport the correct quantities of water of the desired quality at the right times to the places where it is most needed. This problem is agonizing in times of drought, and is never easy at any time, as the following brief observations will show.
The old quality problem is that of salt. Its simplest way of intrusion is the direct way with the tides through the open estuaries. As has been shown already, a lot has been done about that by closing some of the estuaries. But also where there are locks for in- and outward bound sea traffic, each lock cycle lets in large quantities of salt. Finally, there is, in the low polder areas, a constant upward pressure of saline groundwater, constantly salinating the ditches and canals. Salt is also coming in with the water of the Rhine.

There is a natural tendency for salt intrusion to increase as a consequence of the phenomenon of relative sea level rise. But also increased shipping traffic, larger locks, bigger harbours, deeper entrance channels have encouraged salt intrusion. This is especially notable in the Rotterdam waterway, where the intake of fresh water supply for agricultural and drinking water purposes into the western part of the country (Rhine water) had to be gradually moved upstream some 20 km. The Delta works have temporarily improved the situation, but the present inlet is by no means unthreatened. The quantity of river water needed to keep the salt back from the inlet is between 600 and 700 m$^3$s$^{-1}$, which roughly equals the minimum observed Rhine discharge where the river crosses the Dutch border.

As to other substances that pollute the surface water, the Netherlands are no better off than any other densely populated, heavily industrialized modern country. Advanced legislation (that will be dealt with later) and the determination to get the better of this problem have gone a long way to reduce oxygen-demanding pollution and begun to get a grip on chemicals. Like everywhere, organic micropollutants, heavy metals and eutrophication are the most difficult to tackle, while waste heat is also a problem that does not have quick and easy solutions.

All this means that many of the Dutch surface waters are of less than desirable quality. Apart from the usual method of purification at source, a system to get rid of salt and pollution is to "flush" the polder waters: letting fresh water in at one end and pumping dirty water out at the other, removes the unwelcome substances. The ironic fact is, that in the majority of cases this "cleaning" has to be done by Rhine water.

Of the total fresh water supply of the Netherlands, roughly two thirds is water from the Rhine. All large and small rivers together account for about 75%, and rain water for the remaining 25% of the total supply which, on an average, amounts to $110 \times 10^3$
m$^3$ year$^{-1}$, of which 20 x $10^9$ m$^3$ is lost by evaporation. It is no secret that the Rhine, flowing through one of the most heavily industrialized areas of the world, carries an uncommonly high load of polluting substances. It is useless to name them all in a general paper like this, but all categories are represented. It is true that the Federal Republic of Germany has put great effort into reducing the amount discharged of some of the substances; this did result in a gradual decrease of some concentrations and in an improvement of the oxygen content, but the discharge of some of the heavy metals, mutagenic (or suspected) substances, phosphates and nitrates, as well as salt and waste heat have not yet been reduced or are even increasing.

Although the loads of some substances vary slightly with the river discharge, a simplified and not too far fetched assumption is that they are constant. Certainly it is true that low discharges carry the highest concentrations. This means that flushing of polders in dry periods is either useless or is only effective using great quantities of water, that, in such periods, are not available.

It is neither possible nor desirable to give a full description of the situation. But from the foregoing the following general picture does emerge: by damming off its estuaries to protect itself from storms and from salt, the country is able to store and use much of the surface water that is supplied from external sources (mainly: Rhine water). Rhine water therefore occurs in larger or smaller percentages in most of the surface waters in the Netherlands. Fresh groundwater (the much-preferred source for many uses), is available only in part of the country (the south and east, and the dunes along the coast) and, in many regions, is already being used to capacity.

Instead of a description of the problem in general terms, a few examples may suffice. An industry with a high quantitative demand for water but with no special quality demands, may be situated in an area that is difficult to supply with surface water. It has always been using groundwater, that might as well or even rather, be used for other purposes. A horticultural area with very specific demands for water quality could be found in an area where water is abundant but of poor quality: supply with good quality water is unacceptably expensive. Farmers want to sprinkle their crops in times of drought and cannot, legally, be stopped from using surface water meant for other purposes, or from using groundwater and thereby lowering the groundwater table to a degree that may hurt a nature conservation area. Concentrations of electricity demand have no spatial relationship with the presence of cooling water for electricity production. Water level control of the IJssel Lake moves within narrow limits: 0.2 m (summer) to 0.4 m (winter) below national zero level; any intention to widen these limits meets with a host of conflicting interests. As supply is generally abundant in winter and spring, excess storage is needed because of the non-existence of long term drought predictions. Prevention of massive salt intrusion through the Rotterdam Waterway uses an unreasonable percentage (up to 100 in times of drought) of the national fresh water supply. Industries and concentrations of population discharge pollution into water bodies, that might otherwise be used beneficially for various purposes. Recreation, nature conservation and ecological equilibria are often helpless victims of (in many cases respectable) activities
of other parties.

A complete and specified list of these problems would occupy many volumes. They were, in fact, a basic set of inputs to the PAWN study. It had to think up "tactics" to tackle single problems, merge these tactics into "strategies" and come up with a limited number of promising national policies for policy makers to take their choice. The PAWN techniques and results will be dealt with in the other related papers. The final matters to be dealt with in this paper are descriptions firstly of the difficulty within the Dutch water management system, arising from the political structure and the available legislative framework, of implementing any consistent national water policy, and secondly of how modern legislation is beginning to improve matters.

POLITICAL BACKGROUND AND LEGISLATIVE DEVELOPMENTS

The first settlers in the low countries had to protect their lives and cattle against flooding from the sea. This led to the creation of "polders", and already in the Middle Ages single polders or combinations of them were united into administrative bodies, "water boards", in which landowners had democratic rights to elect their governing board: this is the earliest form of government administration in the Netherlands. More recent forms include dyke boards, storage basin-boards and water purification boards. All types, old and new, still exist and have an important function in the administrative structure of the country.

In the sixteenth century, the Netherlands were still no more than a set of autonomous provinces. Only in the seventeenth century did the country emerge as a united political state. The fact that provinces nowadays carry relatively great political powers is reminiscent of this historical background. Municipalities and water boards operate with a high degree of independence, but have the provincial authorities as their "bosses". The central government, of course, has the supervision and final say in many matters, also in matters regarding the safety, distribution and quality of water. The central government and the governing bodies of provinces and municipalities are so-called "general democracies". The governing boards of the water boards are elected by landowners.

In a country like the Netherlands, as described above, it is not surprising that all levels of government have responsibilities in water management. Some 10-20 years ago the division was, roughly speaking:

- responsibility for safety and navigation: central government and provinces;
- responsibility for water levels and internal distribution: water boards;
the responsibilities of municipalities were incidental and related to any of the categories.

Subsequent developments that took place were, among others: concentration of water boards and creation of boards with specialized responsibilities, such as: dyke management; storage area management; water purification (after the Water Pollution Act came into force). The general picture, however, has always been a very
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decentralized form of government, with separated responsibilities, 
hanging together by traditional codes of conduct. All this has been 
functioning surprisingly well for many centuries. 

However, the modern developments of population growth, 
industrialization, pollution etc., call for integrated water 
management policies. These developments brought to light 
insufficiencies regarding comprehensiveness of the ways in which 
decisions were taken, regarding the instruments of control, and also 
regarding the powers of the government in unusual circumstances. 
Some examples of the kind of problems that arose are:

(a) The manifold considerations and interests concerned, e.g. in 
the determination of a suitable site for an electricity plant, will 
easily lead decision makers to underestimate the importance of the 
availability of cooling water.

(b) Even if in one place sufficient water of good quality is 
available, often pumping or transport capacities are insufficient 
to bring it to a region where it is needed.

(c) During the dry summer of 1976 no legal obligations existed 
for the polders surrounding the IJssel Lake to limit their 
abstractions; owing to their cooperative way of thinking, they did, 
on request, reduce the amount abstracted.

Many more examples may be added. All of them would serve to 
illustrate the fact that the developments of modern society made it 
increasingly difficult to develop a cohesive and consistent water 
policy. Such a policy would have to weigh the interests of the 
various sectors and regions, and should be able to enhance the 
efficiency of water utilization.

Logically, all this would call for an integrated Water Management 
Act, but the facts of life were that an anti-pollution act was most 
urgent and came first, a groundwater act could, after that, not wait 
until thinking about a general act was completed. The Anti 
Pollution Act, therefore, has been operational since 1970, the 
Groundwater Act has just passed Parliament, and a Soil Protection 
Act, not considered urgent till recently, is receiving accelerated 
attention owing to recent discoveries of many disquieting waste 
dumps.

The Law against Pollution of Surface Waters

The intention underlying this Act is to prevent or combat pollution 
of surface waters by wastes and other polluting or toxic substances. 
The Law forbids discharge of wastes without a licence; it provides a 
system of levies, demands the drafting of a so-called Indicative 
Multi-annual Programme (IMP) every five years, and gives rules for 
the governmental organization of water quality management. For this, 
responsibility concerning the main waters rests with the central 
government. Quality management of all the other surface waters is 
in the hands of provinces or water boards.

The second IMP is now operational; many improvements have been 
achieved, many problems remain. Changes in the Law have been or are 
being realized, owing to national and international developments. 
In the context of this paper it is important to note that the latest 
change demands water quality plans from the central government as 
well as from the lower level responsible bodies: these will,
eventually have to fit into the planning systems of the other water laws.

The Groundwater Act

This law will replace an existing act, that controls abstraction by drinking water companies only. Other groundwater manipulations are being handled in a haphazard way, using legislation that was meant for other purposes.

The new act demands licences for all major groundwater abstractions and for infiltration of surface water into the subsoil. The authority to issue licences is given exclusively to the provinces. This issuing, however, has to be based on a policy, laid down in a provincial groundwater plan. A general groundwater policy of the central government is indispensible: to ensure consistency of the provincial plans with this policy, there are mechanisms to check against it the planning and issuing of licences. A Groundwater Commission will be instituted to advise the government and help, on request, the provinces to draw up and execute their policies.

The Water Management Act

This act provides for a system of licensing (abstraction, discharge, transport of surface water). As, however, in this case the relations are not always between public authorities and private persons (companies) but also mutually between authorities, the law will introduce what it calls "water agreements", dealing with exchange of water quantities and with management of quality. Also, there will be obligatory registration of quantities discharged, abstracted or transported. The government has the power to make emergency provisions.

The essential part of the act will be, however, a system of water management planning. Water boards, provinces and the central government will have the obligation, within certain intervals of time, to draft plans of various types for the water bodies under their respective responsibilities. Some are mere management plans, others surface water quantity plans, but provinces and the central government will draft overall water policy plans; this is a very important feature, because it gives this act the character of an instrument of integration between the various laws dealing with aspects of water management.

The government is now preparing a water policy report to Parliament, that will be published together with the introduction of the law into the parliamentary process. Attempts are being made to make this report as similar as possible to the type of report that the law will demand to be drafted every 10 years.

Papers 2 and 3 will try to show how the PAWN study paved the way to a method of thinking, without which the drafting of the policy report would have been much more difficult, if not impossible. In any case, although PAWN had certain shortcomings, the policy report as well as the Water Management Act itself, are appreciably more sophisticated than they would have been without this very interesting analysis.