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# Ecological water management in practice

Proceedings and Information No. 45
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**Ecological Water Management in Practice** (Proceedings of the technical meeting held in Ede, The Netherlands, 3 October 1990). Proceedings and Information CHO-TNO, no. 45, 1991.

# INTRODUCTION

A.J.A.M. Segers

A large part of the Netherlands consists of wetlands; the Dutch created land from water but created also water in reclaimed land. This activity became clearly visible in the polder landscape with its numerous canals, ditches and shallows lakes. Rivers were regulated and also most of the brooks on the higher sandy soils. Estuaries were cut off from the sea by dams which prevent normal tidal effects and sea water intrusion. The original flora and fauna was and is affected by these works so that natural hydro-environments are rare in the country. Still existing "natural" hydro-environments survive by the gratitude of special planning and managing water and land, but everywhere water quality is influenced by man, even the quality of groundwater.

Nowadays in managing surface water many aspects have to be considered to realize a balanced aquatic ecosystem. Recent studies have provided tools for managers to do so but by far not all problems have been solved at this moment. However, a number of practical tools will be presented in this publication. The current proceedings contain the papers presented at the 49th Technical Meeting of the TNO Committee on Hydrological Research "Ecological Water Management in Practice". This meeting was organized in co-operation with the Advisory Council for Research on Nature and Environment [Raad voor het Milieu- en Natuuronderzoek (RMNO)] and held in Ede, The Netherlands, on 3 October 1990.

The RMNO gave an assignment to two major research institutes together for a research planning study. In this study the ecological aspects of water management with emphasis on regional surface waters were investigated. Several speakers at the technical meeting referred to the results of this study. The RMNO-publication of the study, entitled "Ecological Aspects of Integrated Water Management" [Ecologische aspecten van integraal waterbeheer] (De Vries et al., 1989) was distributed among the participants of the meeting at the end of the day. One of the general conclusions in the RMNO-publication was that not only the presence of knowledge-gaps does restrain the input of ecological aspects in integrated water management but also the exchange of existing knowledge between aquatic ecologists and the persons in the field of water management can be a substantial barrier. The organization of this technical meeting, which was attended by many members of both groups, was a satisfying step in the direction of improving this exchange.

In the first paper L.W.G. Higler is considering the management of surface water from the ecological point of view. Because many different types of water systems are existing there is a need for ecological standards.

In the second paper J.J.P. Gardeniers, presenting some cases, provides information on the measures taken and the results that can be expected.

In the paper of L.A. Deurloo, working at a Regional Waterboard, some aspects of practical water management are discussed and specific problems are elucidated.

J.M.J. Gieske has done a hydrogeological model study in West Twente (part of the Province of Overijssel in the East Netherlands) to get a clear comprehension of the groundwater flow system.

Following P.F.M. Verdonschot deals with reference frameworks, disturbance-effect relations and assessment systems. The assessment of the whole ecosystem is best be met by using a framework of developmental stages of ecosystems: the web-approach.

The next paper of K.J. Provoost deals with the progress that has been achieved by implementating ecological objectives in water management policy. In the Netherlands the water management is handled at three levels: national, provincial and regional.

Finally J.A.W. de Wit gives an overview, conclusions and recommendations.
He deals with four questions:

- What is ecological water management?
- What is the state of knowledge for application in practice?
- Is the knowledge available?
- Who should do it, and what is the task of the water authority?

The main conclusion is that ecological water management can provide an instrument for conservation and improvement of ecological conditions is a pre-requisite to achieve a balanced aquatic ecosystem.

REFERENCE

DE VRIES, I., BAAN, P.J.A., HIGLER, L.W.G. and VERDONSCHOT, P.F.M.; 1989. Ecologische aspecten van integraal waterbeheer. Publikatie RMNO nr. 41.

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# ECOLOGICAL WATER MANAGEMENT; CONSIDERATIONS

L.W.G. Higler

## ABSTRACT

Considerations for sound water management from the ecological point of view are:

- the management of surface waters as water systems;
- ecological knowledge needed for water management;
- knowledge of effects of management measures on the water system.

Water systems can be very different in abiotic and biotic characteristics. The main abiotic variables in this respect are: salt content, current velocity, dimensions, permanence, acidity/alkalinity, and trophic status. Ecological knowledge has to be transformed into ecological standards; standards have to be made applicable for water management practice. The knowledge of effects of measures on the ecology of the water system is insufficient; however, general rules can be given. Examples are shown. Water management has influence on quantitative processes and/or fluxes of substances. Most surface waters and groundwater in the Netherlands are affected in this way. Ecological water management can provide an instrument for the conservation and improvement of ecological conditions.

## 1 INTRODUCTION

Since 1986 the term integrated water management is used in the Netherlands (Ministerie van Verkeer en Waterstaat, 1986). The most important goal is harmonization of functions. In practice this is generally difficult to achieve, especially if the function nature and ecological integration of measures is considered. In this respect, it is important to know how the ecological characteristics of waters change in a positive or negative way as a result of changes in the realization of other functions (De Vries et al., 1989). The knowledge of these ecological characteristics and of the effects of management measures on the ecology of waters is still imperfect.

Ecology is the study of the relationships between organisms and between organisms and environmental factors. In each water plants and animals occur and many types of relationships can be observed. Animals eat plants and other animals, plants produce oxygen and constitute hiding places and substrate for animals. The biocommunity thus formed depends on nutrients and other abiotic variables of the water body. Management affects the ecological functioning of waters, because it causes changes in abiotic characteristics.

Ecological water management is such a management that does not harm or, if possible, improves the ecological functioning of a water body. Water body must be interpreted as the total water system in the sense of the Third Note on Water Management [Derde Nota Waterhuishouding] (Ministerie van Verkeer en Waterstaat, 1989). This concept is represented in a simplified form (Figure 1) and it is related to the term integrated water management. This means that a surface water must be considered in connection with other components of the natural system such as groundwater, water bottom, substances in the water and aquatic biocommunities.

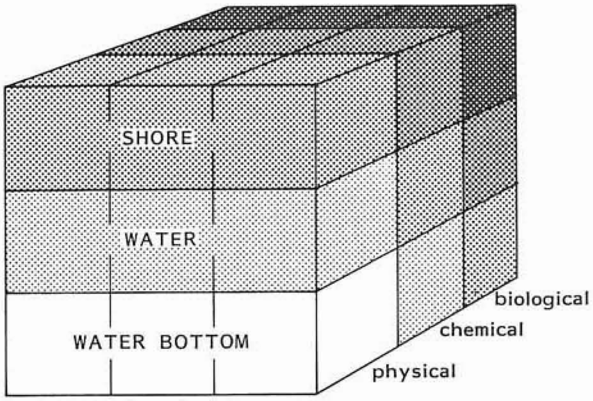



Figure 1 Simplified representation of a water system (Third Note on Water Management)

In this contribution the question will be treated which considerations from an ecological point of view are relevant for a sound water management and also the relevance of water management for ecology.

## 2 THE WATER ECOSYSTEM

Water as a component of the landscape is more than $H_2O$ (Schroevers, 1967). The different ways of water use implicitly accept that. An obvious example is the fisherman's approach. The compartments of the cubic of Figure 1 are related to each other in a logic way and together they constitute the water system, which is one of the most important considerations of ecological water management. It implies that a management measure taken in one of the components generally will affect the other components. For that reason, it is necessary to know the connection between the components in order to be able to predict the results of different management measures. This knowledge is needed to prevent undesirable effects, but also to create desired situations. The science that is required, is the aquatic ecology. Ecological knowledge is the second important consideration for ecological water management. The concept water system is fundamental in aquatic ecology, but it is a matter of discussion where to draw the boundaries of the system. In the practice of water management the same problem arises and then it is combined with territorial administrative limitations (Colijn and Leentvaar, 1990). These authors write "The object of management is and will always be the water. Management of the shore is not primarily directed to the shore as such, but to the shore as part of the natural water system. It helps if the practice of the shore is in the hands of the water manager, but it is not necessary. Co-operation with other administrations is extremely important. The water manager is not an environment manager, but sound water management is a great help for sound management of the environment." This illustrates the dilemma of many water managers. How far do you go out of the water, literally as well as figuratively.

Taking water as an ecosystem for a starting point, ecological water management can be redefined as such a water management that guarantees an optimal development of the aquatic ecosystem. We therefore need sufficient knowledge of the effects of management measures on the functioning of ecosystems and that is the third important consideration for ecological water management. In the following sections the considerations will be further elucidated.

## 3 WATER SYSTEMS

Water management in the western part of the Netherlands deals with other types of water systems than in the Pleistocene provinces in the south. Ditches, canals and lakes in peat and clay areas are characterized by other features than streams, bog pools or the river Meuse. Different water types are concerned and the filling in of the compartments of Figure 1 for these types must show great differences. A chloride concentration of 1000 mg/l can be very normal in a ditch in the western part of the Netherlands, but the same concentration in any water in the province of Limburg (southern part of the Netherlands) is an indication of serious pollution. In bog pools a low pH is generally normal and a high nutrient content is undesirable. A stream is supposed to have a regular current, but this is not the case with ditches. Therefore, it is very difficult to issue national standards. Of course it is possible to do this for certain functions of water bodies, but for the approach of waters as ecosystems a differentiated treatment is needed. The government has realized this and formulated the principle in the third Indicative Plan for Water Mangament (Ministerie van Verkeer en Waterstaat en Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, 1986). An elaboration has been given in the CUWVO V-1 Note (CUWVO, 1988). Some of the most important characteristics or master factors for the ecology of waters are given below.

a. Salt content.

   A high concentration of ions affects the osmotic processes in organisms. In the Netherlands mainly chloride ions are considered. If the concentration rises above 300 mg/l, the first effects on certain freshwater organisms can be demonstrated. The higher the concentration, the more a change from freshwater to brackish water communities can be observed. Freshwater organisms disappear and are replaced by plants and animals that need the higher concentrations (Figure 2).

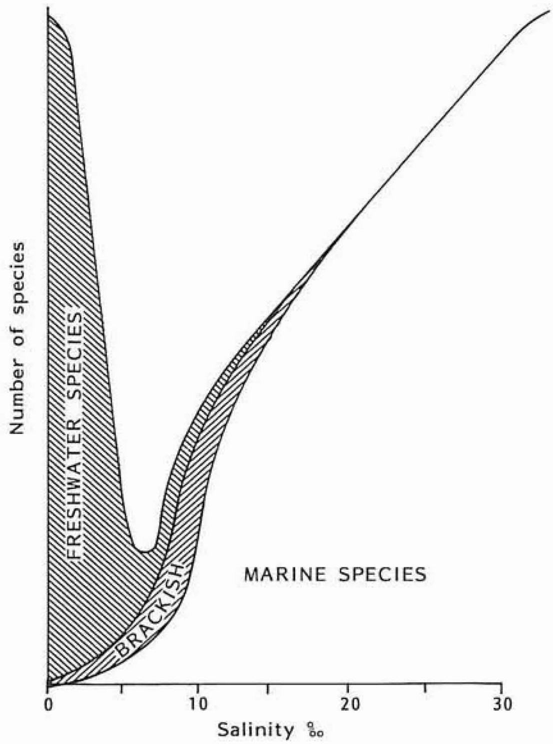



Figure 2 The number of species in relation to salt content (Remane, 1934)

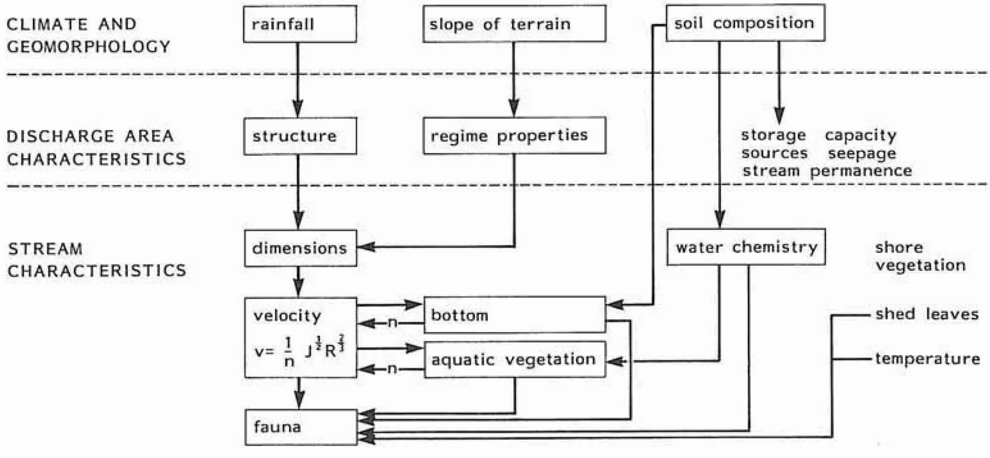



Figure 3 Hierarchical scheme of factors that influence invertebrates in streams

b. Current velocity.

A more or less comparable phenomenon as with salt content can be shown. There is a gradual sequence from stagnant water to whirling mountain streams. There are no common plants and animals in both extremes, but there is a continuum of biocommunities in relation to the current velocity. The slower the current the more similarity there is with communities from ditches. In mountain streams no higher waterplants grow, in ditches many and in lowland streams also quite a number can be found. Figure 3 demonstrates in a hierarchical way the most important factors that influence the fauna of a certain stream section. Hydraulic factors are dominating.

c. Dimensions.

The dimensions and especially the depth of a water body affect properties like light penetration, plant growth, temperature conditions, permanence etc. Water plants and most aquatic animals are restricted to water bottoms; the deeper the water body, the more "empty space". This does not hold for planctonic organisms and sometimes fish. A water body with a vast shoreline contains much littoral vegetation and fauna belonging to it. In deep waters the diversity of the fauna decreases strongly with depth (Figure 4). Shallow water bodies can be filled up with water plants and one can say that it is merely an overgrown bottom. Underwater shores can be considered as a

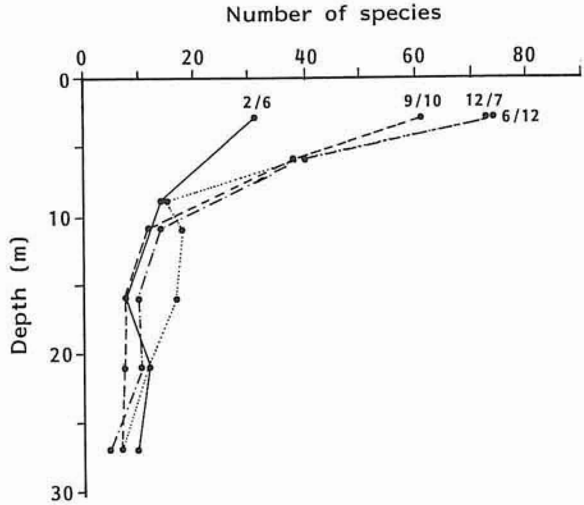



Figure 4 The distribution of the benthic fauna in Lake Maarsseveen in relation to the depth (Higler, 1981)

vertical extension of the bottom, like in ditches. In those cases they constitute an ideal nursery and hiding place for aquatic invertebrates (Higler and Verdonschot, 1989). The dimensions of small upper courses of streams differ so much from those of the lower courses of large rivers, that also for this reason no common organisms will be found. Still both types constitute compartments of one system in which the dimensions gradually change from source to mouth.

d. Permanence.

Some water bodies dry out during a shorter or longer period. This is a disaster for aquatic organisms, but since there is often a certain periodicity, quite a few species have adapted to these circumstances. Insects can leave the water and lay eggs that only start developing after filling up of the water body. Some animals dig holes in the bottom and stay there until the water comes and so there are many adaptations. The plants and animals living in temporal water bodies constitute a certain selection of more or less characteristic species.

e. Acidity.

Water bodies with a low pH contain a very typical biocommunity, because certain adaptations are required to survive. The lower the pH, the more difficult the survival and the more typical the biocommunity. At pH 6 the internal acid/base equilibrium starts to be disturbed; at pH 5.5 the Ca regulation is affected and at pH 5 the Na regulation; at pH 4 respiration is affected and the other mentioned physiological processes have an increased effect. At low pH only well adapted organisms survive and nearly all of these are not found in neutral waters. In the Netherlands bog pools and some sources and upper courses of streams are concerned.

f. Trophic status.

The degree of trophic status is predominantly determined by phosphate and nitrate, the nutrients for algae and higher water plants. If the nutrient content is low, the water is clear and the numbers of specialized algae, mosses and higher water plants are generally low. Animals in these waters mostly are specialized as well. Low nutrient content goes often together with low(er) pH. If nutrient content increases, the biocommunity becomes more diverse, but if it becomes too high algal blooms may occur that suppress the growth of higher plants. This leads to loss of structure and therefore to the disappearance of animals. If instead of green algae the so-called blue greens are dominating, then the last stage of the sequence is reached. The biocommunity is then strongly impoverished; few species in high numbers. The sequence from low in nutrients (olitrophic) to overrich (hypertrophic) can occur in most water types, but the beginning is not necessarily always oligotrophic.

The mentioned features belong to relatively undisturbed situations. Many human activities influence the ecological functioning of waters, such as acid deposition, organic loads (saprobity), canalization, influence of Rhine water and such-like.

## 4 KNOWLEDGE OF ECOLOGY

It is a matter of course that ecological knowledge is required for ecological water management. This knowledge must be available for management practice in the form of ecological standards and these have to be transformed for concrete waters and actual problems. These are two steps between theory and practice and on its way many things can happen. The first question is: is there sufficient knowledge of the ecology of waters to produce standards for water management?

In aquatic ecology research is performed about the structure and the functioning of aquatic systems. The structure describes a certain situation with abiotic and biotic variables. It is a more spatial approach and concrete results for application are typologies, classifications and methods for biological water quality assessment. In water management practice this is a well used tool (a.o. CUWVO V-1 Note). The functioning of systems asks for another approach. Here processes in time are studied, budgets of C, N or P are made and primary production is measured. The existing knowledge in the Netherlands is fragmentary as far as the totality of water types is concerned. Still we need knowledge in the field of processes for sound management (De Vries et al., 1989). In many cases one wants to change a certain situation and reach another situation. These situations can be described in terms of structure, but the management measures to go from one to the other situation affect generally hardly known processes.

An additional problem is the lack of knowledge about the desired situation (see Verdonschot's contribution in this volume). If one is able to describe the abiotic and related biotic characteristics of all kinds of water systems, standards can be derived. An example of this is an ecological classification (Verdonschot, 1990a). In the discussion about current velocity is stated that hydraulics are of eminent importance for the distribution of aquatic invertebrates in streams. Higler and Mol (1984) constructed a diagram using hydraulic factors from the formula of Manning to define running waters. In Figure 5 the distribution pattern of five species of water insects is depicted in relation to hydraulic factors.

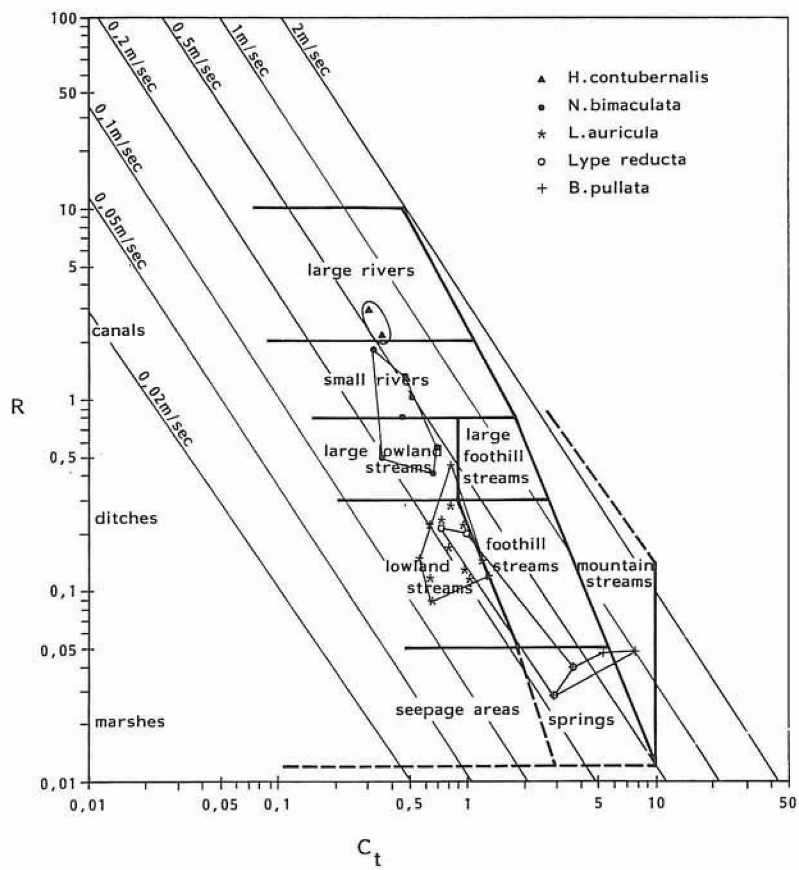



Figure 5 The distribution of five caddies larvae in relation to hydraulic factors
R = hydraulic radius
$C_t$ = terrain factor (combination of slope and roughness)
v = current velocity

The Commission Ecological Standards for Water Management [Commissie Ecologische normen waterbeheer] has given a good start for standardization of process parameters (Gezondheidsraad, 1984, 1988, 1989), but comments on the third part (Murk et al., 1990) indicate the lack of knowledge about certain important water types for water managers. Moreover, the transformation from theory to practice seems to be absent in many cases. It seems justified to conclude that the step from theory to standards is not yet made in all cases and that the step from standards to practice is still in the phase of stumbling.

## 5 KNOWLEDGE ON THE EFFECTS OF MANAGEMENT MEASURES

There is a long tradition of management of surface waters in the Netherlands, which has started as a quantitative management. In the last decades, qualitative management became more important. Nowadays ecological management is propagated as part of integrated water management. As said before this means that the ecological functioning of waters may not be be disturbed or that it must be improved. Our knowledge, however, seems to be far from sufficient, which does not mean that nothing can be done. There are many considerations that can lead to measures for improvement. A good start is the discussion on master factors (Section 3) and in Verdonschot (1990b) many examples are given.

Some simple rules are:

- Management must link up with natural structures and processes, as determined by geomorphology and climate (for example Figure 3). Especially hydrology is considered in this way.
- Driving back of pollution; water purification; making use of natural filter possibilities without disturbing existing values.
- Promotion of the variation in structures. A meandering stream is better than a canalized one. By staggered dredging of water plants in ditches a more variegated aquatic environment will arise.
- Trees along the upper courses of streams. They provide food (leaves, land insects) shadow and consolidation of shores. It is an attractive element of the landscape and minimizes the costs of management.
- Weirs are not advisable from an ecological point of view. It is better to minimize

drainage in the upstream area, to create flood plains and marshes in order to enlarge the storage capacity and slow down the discharge.

- Do not use the same methods everywhere. What is good in one situation can mean a deterioration in another situation that was already optimal.

These are only a few examples and with the right ecological insight many more can be found. Each situation has its own specific problems and solutions.

## 6 WATER MANAGEMENT IS IMPORTANT FOR ECOLOGY

Nearly all water bodies in the Netherlands are being managed in one way or another. The intensity of management varies from doing nothing to radical manipulations of quantity and (chemical) quality. The ecological effects of management vary accordingly. Generally speaking there are effects in the field of quantitative water management and in the field of fluxes of substances. Many waters are connected with each other directly or indirectly.

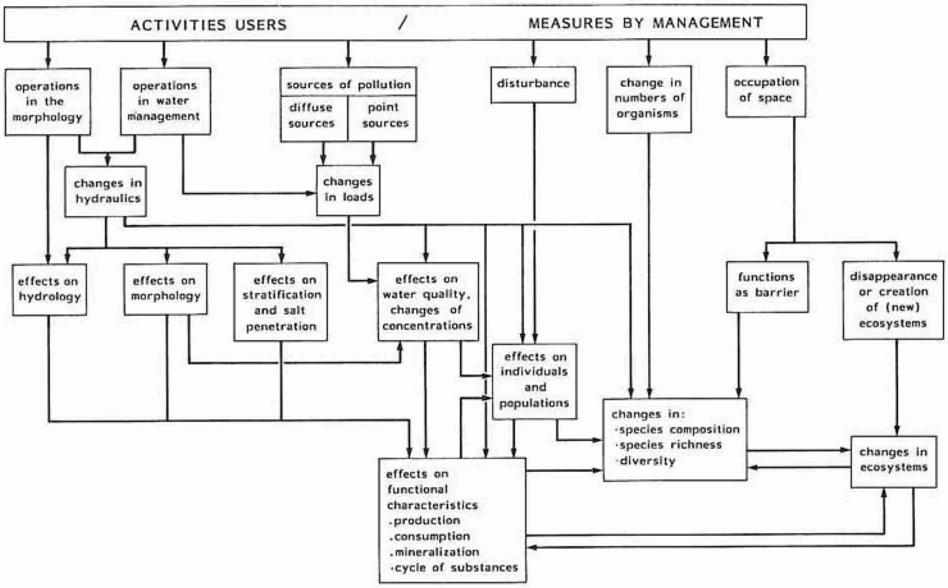



Figure 6 General scheme of intervention-effect for physical chemical and biological characteristics of aquatic ecosystems (De Vries et al., 1989)

Human activities in polders and discharge areas affect ground and surface water of ditches, canals, streams, rivers, and lakes qualitatively and quantitatively. This influence also affects nature reserves.

Water management is being executed with a certain goal and the goal is derived from functions. It will be obvious by now that ecology plays a growing role in water management and official reports and recommendations stress this fact. I should like to say that water management is ecological management. It is true that cooperation must be organized with other administrations active in the field of landscape management. This already follows from the water system approach and especially if the total web of influences is expanded (Figure 6). Ecological water management can be an important tool for conservation and improvement of the Dutch surface waters. Water managers and ecologists are allies.

## REFERENCES

COLIJN, C.J. and LEENTVAAR, J.; 1990. Ecologische aspecten van integraal waterbeheer. Waterschapsbelangen 9, 1990: 275-278.

CUWVO; 1988. Ecologische normdoelstellingen voor Nederlandse oppervlaktewateren; 1-153.

DE VRIES, I., BAAN, P.J.A., HIGLER, L.W.G. and VERDONSCHOT, P.F.M.; 1989. Ecologische aspecten van integraal waterbeheer. Programmeringsstudie. Publikatie RMNO nr. 41, 75 p.

GEZONDHEIDSRAAD; 1984. Advies inzake een begrippenlijst ten behoeve van ecologische normen waterbeheer. GR rapport nr. 84/37, 's-Gravenhage.

GEZONDHEIDSRAAD; 1988. Ecologische normen waterbeheer, deeladvies II: keuze van de parameters. GR rapport nr. 88/06, 's-Gravenhage.

GEZONDHEIDSRAAD; 1989. Ecologische normen waterbeheer, deeladvies III; beschrijving van de parameters. GR rapport nr. 89/21, 's-Gravenhage.

HIGLER, L.W.G.; 1981. Bottom fauna and littoral vegetation fauna in Lake Maarsseveen. Hydrobiol. Bull. 15: 82-86.

HIGLER, L.W.G. and MOL, A.W.M.; 1984. Ecological types of running water based on stream hydraulics in the Netherlands. Hydrobiol. Bull. 18: 51-57.

HIGLER, L.W.G. and VERDONSCHOT, P.F.M.; 1989. Macroinvertebrates in the Demmerik ditches (The Netherlands): the role of environmental structure. Hydrobiol. Bull. 23: 143-150.

MINISTERIE VAN VERKEER EN WATERSTAAT; 1986. Omgaan met water. V&W, 's-Gravenhage.

MINISTERIE VAN VERKEER EN WATERSTAAT; 1989. Derde Nota Waterhuishouding: Water voor nu en later. V&W, 's-Gravenhage.

MINISTERIE VAN VERKEER EN WATERSTAAT and MINISTERIE VAN VOLKSHUISVESTING, RUIMTELIJKE ORDENING EN MILIEUBEHEER, 1986. De waterkwaliteit van Nederland. Indicatief meerjarenprogramma water 1985-1989. 's-Gravenhage.

MURK, A.J., VAN DER SCHRAAF, A.A.A., CUPERUS, R. and DE KRUIJF, H.A.M.; 1990. Strategieën voor ecologische normstelling waterbeheer. Het spel en de knikkers. Verslag van het symposium: Op weg naar een duurzaam milieu, 1 en 2 februari 1990; 96 p.

REMANE, A.; 1934. Die Brackwasserfauna. Zool. Anz. Suppl. 7: 34-74.

SCHROEVERS, P.J.; 1967. Is water $H_2O$. De Levende natuur 70: 273-284.

VERDONSCHOT, P.F.M.; 1990a. Ecological characterization of surface waters in the province of Overijssel (The Netherlands). Thesis Wageningen. 255 p.

VERDONSCHOT, P.F.M.; 1990b. Ecologische karakterisering van oppervlaktewateren in Overijssel. Het netwerk van cenotypen als instrument voor ecologisch beheer, inrichting en beoordeling van oppervlaktewateren. Provincie Overijssel/Rijksinstituut voor Natuurbeheer. 123 p.

VERDONSCHOT, P.F.M.; 1991. The web-approach: a tool in water management. Proc. and Inf. no. 45, CHO-TNO, Delft: 59-76 (This volume).

**Ecological Water Management in Practice** (Proceedings of the technical meeting held in Ede, The Netherlands, 3 October 1990). Proceedings and Information CHO-TNO, no. 45, 1991.

# PROBLEMS AND SOLUTIONS IN ECOLOGICAL MANAGEMENT OF SURFACE WATERS IN THE NETHERLANDS; AN EVALUATION OF ECOLOGICAL MANAGEMENT PLANS

J.J.P. Gardeniers

## 1 INTRODUCTION

### 1.1 Eco(logy)

As early as the first Indicative Plan for Water Management [Indicatief meerjarenprogramma] (Ministerie van Verkeer en Waterstaat, 1975) the notion 'ecology' was used to set standards to the quality of surface waters in the Netherlands. In this plan the "general ecological function" of surface water is even mentioned ahead of the "additional standards depending on the (human) use of the water". An elaboration of the notion 'ecology' and a guideline for implication of 'ecology' in governmental policy was still missing in this plan.

In the first Indicative Plan for Water Management emphasis was put on the sanitation of surface waters. The second and third Indicative Plan for Water Management (Ministerie van Verkeer en Waterstaat, 1981; Ministerie van Verkeer en Waterstaat en Ministerie van Volksgezondheid, Ruimtelijke Ordening en Milieubeheer, 1986) pay more attention to the management of surface waters as aquatic ecosystems. This induced more specific quality standards, regarding both higher quality levels and differences between types of water. The notion 'eco(logy/system)' is used in many different ways and for different levels of quality standards. It is used to describe the functioning of the aquatic system, to formulate water quality objectives, to define quality standards and to indicate assessment methods.

In the Third Note on Water Management [Derde Nota Waterhuishouding] (Ministerie van Verkeer en Waterstaat, 1989) 'ecology' is mainly used in paragraphs describing the "future (governmental policy)". For that purpose "target images" for surface waters have been defined, aiming at "acceptable guarantees for a sustainable ecological development of hydrological systems". The sustainable development is specified as "preservation of production, diversity of species and selfregulation". The "target images" imply also "acceptable guarantees for a sustainable use of the watersystems by man". The "target images" reflect the "possibilities of development of the hydrological systems related to their use by man".

With this the ecological objectives are not only aiming at limited ecological sectors in society, but have become general guidelines for all human activities.

## 1.2 Integrated Water Management

The growing concern for environmental issues led almost automatically to a - also political - reflection on the complex relations between organisms, biotic communities, abiotic factors and intended and not intended human influences. In governmental plans and notes this reflection is echoed by the use of notions like "to do and to let" (CUWVO, 1988) and "handling water" (Ministerie van Verkeer en Waterstaat, 1985). These notions express the growing awareness that management of water quality includes more aspects than initially were meant by the Law on the Pollution of Surface Waters dating from the seventies. The possibility of attaining ecological objectives in water quality management depends heavily on an appropriate management also of water quantity. Already in the sixties Schroevers (1967) put the question: "Is water $H_2O$?". The answer is given in the eighties and nineties: water is a complex (eco)system with a morphological and functional coherence, with regional and typological differences and with several and different uses, both for nature and man.

To indicate this idea of water as a complex ecosystem the notion 'integrated water management', i.e. 'complete water management', has been introduced. In practice the notion 'integrated water management' is used for all water management with multiple aspects or interests involved. 'Integrated water management' fits to local plans with restricted interests and problems, but also to plans with many, maybe all, aspects from technical to administrative ones including the final assessment and balancing of (political) interests.

Notably ecological aspects and interests caused the need for an integrated approach of water management. It may be expected that especially ecological objectives form the core of integrated plans.

## 1.3 Quality objectives, target and reference values

The question how to formulate quality objectives and to define target values and reference values has been the topic of many discussions (Verdonschot and Higler, 1987; Brouwer et al., 1990; Van der Schraaf et al., 1990; Murk et al., 1990). The final wording of the quality objectives in the governmental plans and the definition of the relating target values and reference values of parameters chosen will reflect the views of the managers and politicians.

## 1.4 Aspects to evaluate

For an evaluation of some major management plans the questions to put will be arranged to the above-mentioned main notions: ecological objective, integrated approach and ecological target values and reference values. Attention will be paid as well to common tendencies as to characteristic differences regarding:

- direct and related objectives;
- operational approach of the plan;
- authorities involved;
- financing;
- integrated approach;
- ecological approach;
- interests involved;
- relevant environmental factors studied;
- type of water;
- type of research;
- planning of restoration;

- chance of success;
- future actions.

The following plans will be evaluated: the integrated water management of the lakes of the Gooi-Utrecht area (Van Liere et al., 1989; Ecotest, 1990; Visser et al., 1989), the restoration of lakes from eutrophication in the Rijnland area (Klapwijk et al., 1988; Anonymous, 1988 and 1989a; Van der Vlugt et al., 1990), the water management plan of the Regge and Dinkel area (Van Selm, 1990; NVA, 1990; Deurloo, 1990 and 1991) and the study of the attainability of ecological objectives for the area of the streams of Chaam (Latour et al., 1988; Anonymous, 1989b; Van Zanten and Glasbergen, 1990).

It would be premature to deduce already a manual for ecological management from these studies. Many plans are still in an early phase of execution. Only after a series of years a complete evaluation of the results of ecological management can be made, both for ecological and administrative aspects. To facilitate the composition of a manual, arrangements will have to be made to ensure a reliable comparison between the results of the different plans, both for existing and future ones.

## 2 SYNOPSIS OF SOME PLANS

To show the characteristics of plans for the ecological management of surface waters for example a short survey will be given of some plans.

### 2.1 Nieuwkoop lakes area

Data

- has the highest water quality objective "because of the function of the area, i.e. nature area with high aquatic value";
- can be divided in two parts: a lake and a marshy area with low P-loading (quality class II) and a pasture area with quality class IIIA;
- is characterized by a continuing dominance of blue algae;
- is hydrologically rather isolated;

- intake and outlet of water mainly at the same point;
- P-loading by intake water (65%), agriculture (24%), untreated sewage (6%), precipitation (3%) and drainage water (1%);
- internal P-loading is 28% of the total annual P-loading.

Measures taken

- reduction of intake water (P-reduction of 5%);
- separation of water from agricultural and nature-area (P-reduction of 13%);
- dephosphatizing of intake water gives P-reduction of 45%;
- diversion of untreated sewage (P-reduction of 8%);
- decrease of water used for regulation of the water level (P-reduction of 10%);
- flushing of the lakes with dephosphatized water.

Expected effects

- decrease of external gross P-loading with about 80% (from 0,92 to 0,18 g $P/m^2/y$);
- subsequently also decrease of internal loading;
- in one of the lakes (Noordeinderplas) quality objective class II will be attainable;
- in the other lake (Zuideinderplas) quality objective "basis-quality";
- to predict future water quality more precisely integrated modelling is recommended;
- at least a 5 years research is necessary to follow effects.

## 2.2 The Geer lake

Data

- Geer lake with surrounding area is nature area;
- strongly eutrophicated by former discharges of sewage;
- dominance of filamentous blue algae;
- dominance of bream;
- at the moment only slight external P-loading;
- high internal P-loading by release from bottom.

Measures taken

- hydrological isolation;
- own inlet;

- careful dredging of upper bottom layer;
- P-removal from intake water (P-reduction from 0,71 to 0,14 mg P/l);
- supplementary to P-removal construction of a marshy area with helofytes (additional P-reduction of 15-40%).

Expected effects

- reduction of P-loading to the very low value of 0,08 g P/m$^2$/y.

## 2.3 Reeuwijk lakes

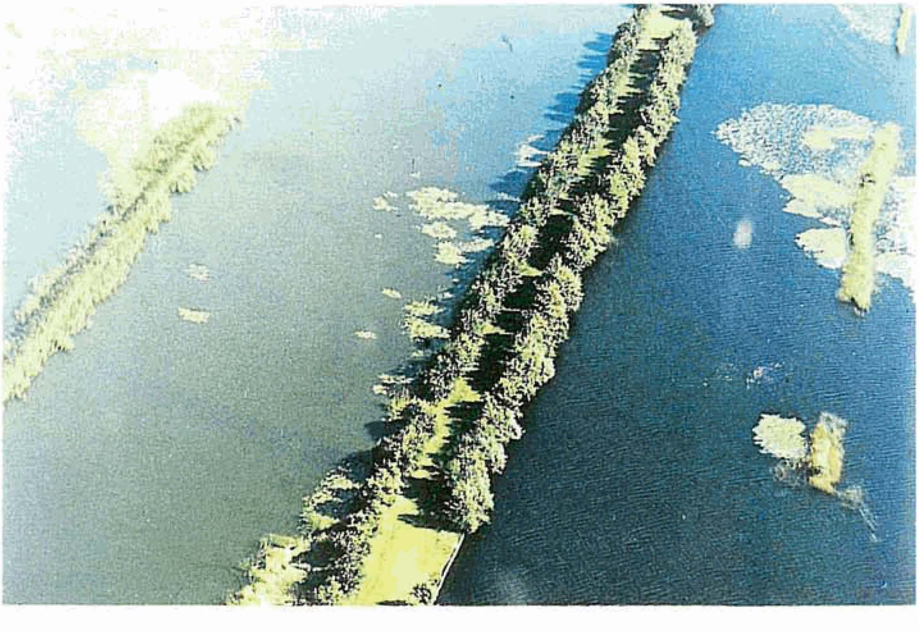
Data

- situated in nature area, hence with a high potential value;
- water quality objective class IIIA;
- dominance of filamentous blue algae;
- P-loading with eutrophic water from effluent of a sewage plant by way of supplying water for regulating the level of the lakes;
- dependent on the point of inlet chosen the effluent reaches the lakes themselves;
- P-loading by untreated sewage (24%), by inlet water (15%), by overflow from polder (9%), from recreational activities (9%), by precipitation (11%) and from agriculture (32%);
- P-loading decreased with 30% by dephosphatizing;
- relation between phosphate and chlorophyll is not clear;
- dominance of bream.

Measures taken

- transfer of point of discharge of effluent from polder to 'boezem' water;
- sewering of ribbon-building area;
- reduction of overflow from polder;
- reduction of inlet water;
- reduction of influence of agricultural area;
- biomanipulation by catching bream and stocking with pike;
- increase of hiding-places for young fishes;
- P-fixation by injection of iron-chloride.

Peat lake



Eutrofic peat lake left and mesotrafic peat lake right

Rhine at "Blauwe Kamer" with high water level

Brook in the dry year 1976

Expected effects
- target is quality class IIIA: only moderate primary production and biotic community rich in species and individuals;
- effects depend on the type of measures taken within a period of 1-5 years;
- biomanipulation and injection of iron-chloride show good results at least at short notice.

## 2.4 Lake Naarden

Data
- nature area;
- decrease of water quality from the seventies on;
- disappearance of Characeae and decline of aquatic macrophytes;
- increase of summerbloom of algae;
- shortage of water by extraction of groundwater in the Gooi area and by lowering of water levels in the surrounding polders;
- supply of dephosphatized water from the lake IJ did not cause the wanted recovery;
- P-loading by seepage water (about 47%), by intake water (about 14%) and from precipitation (about 39%);
- the quality objective is a situation with dominance of Characeae and aquatic macrophytes;
- the lake is an aquatic-ecological "area for attention" category B (with higher standards than "basis-quality", class II or IIIA) and category D (preservation of hydrological patterns);
- management objectives aimed at nature conservation for the surrounding areas.

Measures taken
- reduction or stopping of extraction of groundwater;
- higher water levels in the surrounding areas;
- more variation in water level in the Naarden lake itself;
- improvement of the dyke to stop filtering of water;
- suppletion with dephosphatized water from the lake IJ or with water from the surrounding polders;
- reduction of nutrient loading by dredging;

- reduction of pollution of the groundwater in the Gooi area;
- management of marshy areas;
- reduction of the splitting up of the landscape to foster the return of the otter.

Expected effects

- disappearance of summerbloom of blue algae and filamentous algae;
- return of Characeae;
- return of species rich vegetation;
- at long notice return of otter and osprey.

## 2.5 Lowland streams of Chaam

Data

- the streams have a "specific ecological objective aimed at a function as nature area";
- quality standards are set by the biotic community;
- in the catchment area both nature areas and agricultural areas with intensive cattle and pig farming are present;
- main nutrient loading by agriculture (64% for phosphate);
- some stretches of the streams still inhabit parts of the original biotic community;
- in the centre of the catchment the village Chaam is situated;
- the downstream part is influenced by the effluent of a sewage plant;
- natural values mainly present in the middle- and downstream stretches;
- the different stretches of the streams are involved in different re-allotment plans;
- mostly low discharge, sometimes very high;
- periodical flooding of downstream areas.

Measures taken

- scenario for the development of the ecological quality in which the area is divided in four parts;
- the four parts are related to differences in natural potential and actual (administrative) position;
- improvement or removal of effluent;
- construction of basins to keep water from flooding;

- restoration of meandering;
- (re)planting of trees alongside the streams;
- reduction of dunging and of fertilizer use in some parts of the watershed;
- protection of parts of the catchment area by administrative and planning measures;
- a coherent policy aimed at development of natural potentials of the area by all authorities involved.

Expected effects
- at long notice recovery of the entire catchment area;
- at short notice recovery of some parts (sub-catchments) of the streams;
- recovery and development of a biotic community characteristic for nutrient-poor sandy lowland streams that are partially shaded.

## 3 EVALUATION

It can be observed that at the end of the eighties, and sometimes already earlier, ecological objectives were included in the plans of the regional waterboards. These regional plans give concrete form to the ecological objectives, target values and standards of the plans of the state and the provinces. The approach is always the starting of separate projects for each water body or group of water bodies.

The reasons for selecting certain water bodies to start with are the availability of ecological data, specific problems and practical possibilities. The presence of higher ecological objectives and standards in certain waters does not automatically imply that they will be chosen for further action. The above mentioned examples illustrate that mainly the function of the water body as "nature area" gives rise to measures aimed at the restoration and improvement of the quality of the water. The ecological standard is mostly defined by referring to a former and better situation. This former situation was (at that time) the motive to adhere the function "nature area" to the water body.

Sometimes high costs have to be made for the restoration of degradated aquatic ecosystems. These costs seem to fit in the budget of the waterboards, while part of the money is raised by applying for new governmental subsidies. Most of the plans for restoration of water bodies are still in an initial phase. For that reason it is not possible to foresee if in the future enough money can be set aside for periodical management and maintenance of the restored water bodies. The debate over the desirability of more environmental tasks for the waterboards (Plomp and Van Vliet, in: Van Liere et al., 1989; Segers, 1989) applies mainly to the financial aspects.

The integrated approach by which many different authorities and interests are working together is evaluated as stimulating and successful. The cooperation applies to joint research and joint technical measures, but also to coherent administrative and political agreements aimed at restoration of ecological values. Until now the agreements can not be enforced by law and are only based on consensus.

It can be concluded that the integrated approach as a way of acting is evaluated as very successful. Not more problems are met than in other areas of governmental policy. The involvement of local authorities, organizations and interests in the preparation and implementation of the plans is evaluated as very important.

Preliminary research has been done on the effectiveness of planning-policy by means of an "integrated policy plan" (Van Zanten and Glasbergen, 1990; Van der Veen and Glasbergen, 1990). It showed that this new way of planning is very complex and not yet well organized.

The ecological differences between types of water are reflected in the nature and intensity of the problems that have to be solved and in the nature of the approach chosen. The hydrological characteristics of the area concerned play a predominant part. A first distinction can be made between standing and running water. A second one between lakes with and without seepage.

Table 1 illustrates the importance of knowledge of the hydrological processes for the planning of restoration of aquatic ecosystems. In this table data on the different contributions to the external phosphate loading in seven ecosystems involved in restoration projects are given. Some caution is necessary, because in some plans the hydrological and nutrient budgets do not balance. For that reason only the order of magnitude is relevant.

It is obvious that in the Vinkeveen, the Nieuwkoop and the Sticht Ankeveen lakes (before 1984) the intake water contributes most of the external phosphate loading. In the Naarden and the Ankeveen lakes (after 1986) the contribution by seepage is high. The effect of a preliminary sanitation of incoming water is shown by the big difference in phosphate loading by intake water in the Ankeveen lakes in the period before 1984 and after 1986 (SAP4 compared to SAP6).

Table 1 Categories of external phosphate loading in % of total external phosphate loading for seven projects

| | V | NK | R | N | HAP6 | SAP6 | SAP4 | Ch |
|---|---|---|---|---|---|---|---|---|
| Intake | 64 | 65 | 24 | 14 | 5 | 9 | 77 | 0 |
| Sewage | 36 | 6 | 33 | 0 | 28 | 26 | 6 | 23 |
| Precipitation | 0 | 3 | 11 | 39 | 9 | 6 | 1 | 0* |
| Natural | 0 | 1 | 0 | 0 | 25* | 15** | 4** | 13 |
| Agriculture | 0 | 24 | 32 | 0 | 0 | 0 | 0 | 64 |
| Seepage | 0 | 0 | 0 | 47 | 32 | 44 | 11 | 0 |

* related to open water surface of streams
** mainly mineralization of peat
V Vinkeveen lakes
NK Nieuwkoop lakes
R Reeuwijk lakes
N Naarden lake
HAP6 Holland Ankeveen lakes after 1986
SAP6 Sticht Ankeveen lakes after 1986
SAP4 Sticht Ankeveen lakes before 1984 (before sanitation)
Ch Chaam streams

The totally different nature of streams is obvious. In the Chaam streams the greater part of phosphate loading is by diffuse sources in the catchment area, with a dominance of agriculture.

Related to the more diffuse nature of the water-supply aspects regarding the whole watershed become more prominent, including even influences from outside the catchment and lake area. With that the planning becomes more complicated.

The way the nutrient removal is organized depends heavily on the nature of the sources of nutrient loading. The plans for lakes use a method that can be called the 'tap method'. The already existing, mainly artificial hydrology and its technical infrastructure are used to improve the quality of the water in the lakes. Changes in intake and outlet of water are relatively easy to make. At one point in the lake area, near the 'tap', the incoming water can be dephosphatized. Seepage is much more difficult to handle and large scale measures are needed, regarding both quantity and quality of the seepage water.

Influencing the amount of seepage from the surrounding polders to the lakes is sometimes possible by taking hydrological measures in the polders. This does not hold for catchment areas of streams. The nature of the catchment area and with that the quality of the water coming into the streams are a given starting-point. Only by measures aimed at the nature and intensity of land-use improvement of the quality of the water can be brought about. With that a conflict with agricultural land-use is imminent. Plans for catchment areas of streams pay therefore much attention to aspects of town and country planning, by which (parts of) the catchment area can be protected.

The 'boezem' water finds its place between polder-lakes and running waters. The problems met with in sanitation of boezem-waters are mainly caused by the absence of easy to handle 'taps'. To keep the level in these water, both for shipping and water supply to polders, water of the river Rhine has to be taken in. The 'boezems' are literally connected with the complex problems of a vast catchment area.

In lakes the hydrology is one of the first aspects that can be handled. In streams the hydrology has to be as natural as possible. The stream dynamics is an essential factor that causes the characteristic meandering and variation in bottom substratum. The conflict with agriculture is imminent and essential, because for agricultural purposes the water level should be kept permanently low and the streams should be kept from flooding. This is done by regulating streams into straight canals with weirs and by keeping the current velocity low.

In the plans for lakes the management of water quantity is an instrument for the improvement of water quality by controlling the flow of nutrients. In plans for streams management of water quantity is an instrument to realize the characteristic physical factors for the biota.

In connection with the foregoing, main attention in lakes is devoted to phytoplankton and aquatic macrophytes. Notably the phytoplankton plays an important role in the calculations to set standards and to evaluate results of measures taken. In lakes little attention is paid to restoration of biotopes.

In contrast the plans for streams pay much attention to management and restoration of biotopes aiming at the recovery of the characteristic macro invertebrate community.

Dependent on the importance of internal loading in the nutrient budget, dredging of the bottom of the lakes is one of the measures subsequently taken, after dephosphatizing, sewering and removal of effluent. In some lakes also biomanipulation is employed, which at least at short notice shows good results. Ecological manipulation in streams is mainly aimed at suppressing the bloom of filamentous benthic algae by limitation of light. For that purpose trees are planted alongside the streams. Only in some cases dredging is recommended, e.g. to remove mud polluted with heavy metals (Milieutechniek, 1987).

## 4 CONCLUSION

The integrated approach shows to be an excellent way to handle the complexity of the problems met in ecological water management. Ecological management mainly consists of many interrelated small-scale activities. This scale is reflected in the need for carefully balanced decisions in a situation in which many people with their interests have to come to consensus.

The problems and set-backs met also bring about prudence. A quick and overall improvement of the quality of the water can not be expected. The highest objectives mentioned in the plans are meaningful to set standards, but they are not all attainable. Attention (and money) should be paid to a certain limited (but as many as possible) number of water bodies for which a high ecological standard is desirable and attainable. The management of all other water bodies has to be aimed at least at 'basis-quality' level.

The integrated approach is an outstanding example of interweaving of aspects and interests during discussions and in balancing decisions. The resulting recommendations however mainly emphasize the separation of interests and areas by technical and administrative measures.

In the Third Note on Water Management [Derde Nota Waterhuishouding] (Ministerie van Verkeer en Waterstaat, 1989) 'target images' have been defined that should include 'a development of the water bodies connected with their use by man' and with 'guarantees for a sustainable use by man'. The 'target images' have to be defined more precisely, notably regarding higher ecological objectives.

The integrated plans aiming at ecological management, that have been carried out up to now, rather show a strong restriction or even exclusion of interests other than ecological ones, than a balanced integration.

## REFERENCES

ANONYMOUS; 1988. Project Integrale eutrofiëringsbestrijding Nieuwkoopse Plassen. Hoofdrapport. Hoogheemraadschap van Rijnland, Leiden.

ANONYMOUS; 1989a. Integrale eutrofiëringsbestrijding Reeuwijkse Plassen. Projectvoorstel. Hoogheemraadschap van Rijnland, Leiden.

ANONYMOUS; 1989b. Beleidsplan integraal waterbeheer Chaamse bekengebied. Provincie Noord-Brabant, 's-Hertogenbosch.

BROUWER, E., DEKKER, J.N.M., NIEUWDORP, G.H.E. and VAN DER SCHRAAF, A.A.A.; 1990. Strategieën voor ecologische normstelling, de knikkers en het spel. SDU, 's-Gravenhage.

CUWVO; 1988. Ecologische normdoelstellingen voor Nederlandse oppervlaktewateren.

DEURLOO, J.A.; 1990. Praktische oplossingen? Waterschapsbelangen, 75: 667-674.

DEURLOO, J.A.; 1991. Practical solutions? Proc. and Inf. no. 45, CHO-TNO, Delft: 37-50 (This volume).

ECOTEST; 1990. Naar een natuurconvenant voor het Naardermeer. Technisch rapport.

KLAPWIJK, S.P., VAN DER DOES, J. and VAN DER VLUGT, J.C.; 1988. Eutrofiëring in Rijnland. $H_20$, 21 (17): 474-493.

LATOUR, P.J.M., WITTE, J.Ph., AALDERINK, R.H., GARDENIERS, J.J.P. and VAN DER HOEK, D.; 1988. Haalbaarheidsstudie ecologische doelstelling Chaamse beken. Werkrapport en samenvattend eindrapport. Vakgroep Natuurbeheer, Landbouwuniversiteit Wageningen.

MILIEUTECHNIEK; 1987. Dommel wacht milieuveilige sanering met 450.000 $m^3$ vervuilde baggerspecie. Nr 3: 54-59.

MINISTERIE VAN VERKEER EN WATERSTAAT; 1975. De bestrijding van de verontreiniging van het oppervlaktewater. Indicatief meerjarenprogramma 1975-1979. 's-Gravenhage.

MINISTERIE VAN VERKEER EN WATERSTAAT; 1981. Indicatief meerjarenprogramma water 1980-1984. 's-Gravenhage.

MINISTERIE VAN VERKEER EN WATERSTAAT; 1985. Omgaan met water, naar een integraal waterbeleid. 's-Gravenhage.

MINISTERIE VAN VERKEER EN WATERSTAAT and MINISTERIE VAN VOLKSHUISVESTING, RUIMTELIJKE ORDENING EN MILIEUBEHEER; 1986. De waterkwaliteit van Nederland. Indicatief meerjarenprogramma water 1985-1989. 's-Gravenhage.

MINISTERIE VAN VERKEER EN WATERSTAAT; 1989. Derde Nota Waterhuishouding. Water voor nu en later. 's-Gravenhage.

MURK, A.J., VAN DER SCHRAAF, A.A.A., CUPERUS, R. and DE KRUIJF, H.A.M. (red); 1990. Strategieën voor ecologische normstelling waterbeheer, het spel en de knikkers. SDU, 's-Gravenhage.

NVA-STUDIEDAG/EXCURSIE; 1990. Integraal waterbeheer in Twente. Natuurontwikkeling langs Twents water: 'je moet toch ergens beginnen ?'. $H_2O$ 23 (11): 292-294.

SCHROEVERS, P.J.; 1967. Is water $H_2O$ ?. De Levende Natuur 70: 273-284.

SEGERS, A.J.A.M.; 1989. Landinrichting en waterbeheer in de volgende eeuw. Landinrichting 29: 26-30.

VAN LIERE, L., ROIJACKERS, R.M.M. and VERSTRAELEN, P.J.T. (red); 1989. Integraal waterbeheer in het Goois/Utrechts stuwwallen- en plassengebied. Rapporten en nota's CHO-TNO no. 22, 's-Gravenhage.

VAN DER SCHRAAF, A.A.A., DE KRUIJF, H.A.M. and CUPERUS, R. (red); 1990. Strategieën voor ecologische normstelling, het spel en de knikkers. SDU, 's-Gravenhage.

VAN SELM, J.; 1990. Het waterbeheersplan 1989-1994 Waterschap Regge en Dinkel. Waterschapsbelangen 75 (2): 38-42.

VAN DER VEEN, J. and GLASBERGEN, P.; 1990. Mogelijkheden en beperkingen van integrale beleidsplanning voor grotere wateren. Deelrapportage 1. Twee integrale aanpakken voor de randmeren: de STIBIJ/CIBIJ en de BOVAR. Interfacultaire Vakgroep Milieukunde, Rijksuniversiteit Utrecht.

VAN DER VLUGT, J.C., KLAPWIJK, S.P. and RAAT, A.J.P.; 1990. Visstandbeheer en waterkwaliteit. Eerste resultaten van een experiment in Klein Vogelenzang (Reeuwijkse plassen). $H_2O$ 23 (5): 118-121.

VAN ZANTEN, I. and GLASBERGEN, P.; 1990. Mogelijkheden en beperkingen van integrale beleidsplanning voor grotere wateren. Deelrapportage 2. integrale beleidsplanning voor de Chaamse beken. Interfacultaire Vakgroep Milieukunde, Rijksuniversiteit Utrecht.

VERDONSCHOT, P.F.M. and HIGLER, L.W.G. (red); 1987. Biologische waterbeoordeling: instrument voor waterbeheer? Werkgroep Biologische Waterbeoordeling/Rijksinstituut voor Natuurbeheer, Leersum.

VISSER, C.M., VERSTRAELEN, P.J.T. and ROIJACKERS, R.M.M.; 1989. Baggerrapport in het kader van het proefproject Ankeveense en Kortenhoefse plassen: het baggeren overwogen. Zuiveringschap Amstel en Gooiland/Landbouwuniversiteit Wageningen.

**Ecological Water Management in Practice** (Proceedings of the technical meeting held in Ede, The Netherlands, 3 October 1990). Proceedings and Information CHO-TNO, no. 45, 1991.

# PRACTICAL SOLUTIONS?

J. A. Deurloo

## ABSTRACT

Ecological water management is concerned with the development and maintenance of an acceptable, ecologically sound, water system in the watercourse and its immediate surroundings. Whether it is possible to reach and then maintain the projected situation depends on many factors. One of these factors is the availability of sufficient water of a high quality. The land use along the watercourse is another factor. The volume of water depends on, among other things, the retention in drainage works. Practical solutions to restore water systems include resisting of water withdrawal locations and the reduction of the drainage base in higher areas. The second condition may be fulfilled by coordinating land use and water use.

## 1 INTRODUCTION

All types of watercourses, rivers, streams, etc., whatever their name, have two general functions:

- water drainage, transport and storage: the hydraulic function;
- the ecological function.

Watercourses also have use-functions which depend on the use made of the water and adjoining land. Integral water management entails the optimal fulfillment of all the functions of a watercourse. It is obvious that the management of a watercourse in a purely agricultural area entails a completely different kind of management (in the wider sense of the word) than that of a stream in a conservation area. This means that the ecological aspect of water management is not clear cut, rather it depends on the type of surface water considered. However, there is some correlation between the extent to which both general functions are fulfilled.

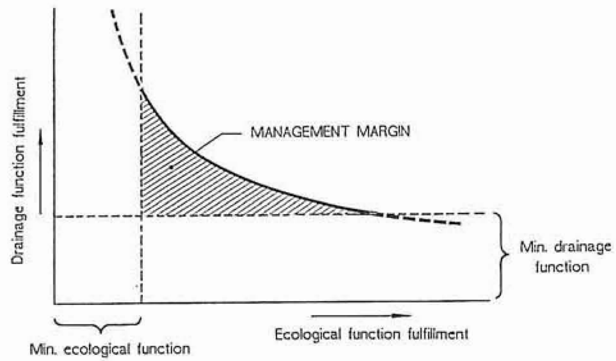



Figure 1 Correlation between the fulfilment of the functions drainage, water transport, storage and ecology

Management is restricted to the shaded area in Figure 1. In physical and chemical terms the minimum ecological function fulfilment can be considered as the General Environmental Quality as defined in the Third Note on Water Management [Derde Nota Waterhuishouding (DNW)] (Ministerie van Verkeer en Waterstaat, 1989). The vertical line is therefore a fixed limit.

## 2 CONSTRAINTS

In the DNW this area falls within the target situation i.e. that there are acceptable guarantees for the development of a system with long-term stability. Some key aspects are maintenance of productivity, type and diversity and autogenous control. However, there are many factors which impose constraints or which may even interfere. These will have to be eliminated first. Besides technical factors there are also factors of a governmental, legal or financial nature. Some of these are outside the direct scope of influence of the water manager. One of the objectives is to reach the general environmental quality as numerically described in the DNW. Given the specific circumstances it will often not be feasible to reach this numerical quality standard in inclined sandy areas due to:

- the limited amount of surface water.

  In many inclined areas the area of open water is very small. A share of one percent or even less is not exceptional. During the growing season watercourses may increasingly fall dry or the flow may be interrupted as the water level falls below the weirs. This is a consequence of irrigation of farmland, groundwater withdrawal for drinking water, land development projects, an increase in paved areas, etc.
- any (residual) contamination present.

  Contamination and residual contamination are generally due to the discharges of waste water treatment plants, overflow water from sewers, leaching and run off of agricultural fertilizers and pesticides, continued release from contaminated beds of watercourses and deposition.

A number of factors influencing water quality cannot be influenced directly by the water manager. Figure 2 shows the responsible authority for each factor in the outer section. This may be more than one authority.

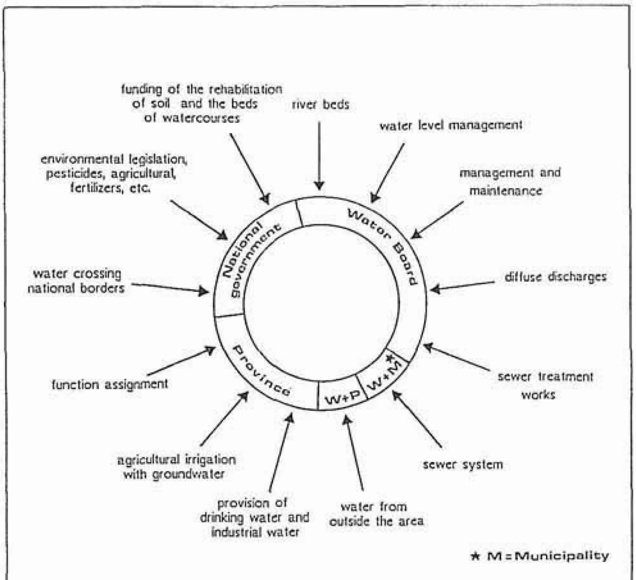



Figure 2 Factors influencing water quality and the authority responsible

# 3 PROBLEMS IN IMPLEMENTING FUNCTIONS

Problems may arise in the form of:

- external factors;
- internal factors.

## 3.1 External factors

This concerns factors which the waterboard (waterschap) may attempt to influence through discussions, but which do not fall within its remit.
Some important examples of this are:

a. Use of groundwater for the provision of potable water and industrial water (including cooling water) and irrigation in agriculture.
   In an average year (on a climatological basis), approximately 20% of the excess rain in Twente (in the eastern part of the province of Overijssel) is used for potable or industrial water or agricultural irrigation. Geohydrological investigations have shown that potable water production may lead to great reductions in the groundwater levels by changing the direction and size of seepage streams.

b. Construction of development schemes, industrial estates, etc.
   Development schemes and industrial estates may directly affect the quantitative and qualitative management. Waterboards hardly have any influence on the decision making process concerned with location, scale, sewer system and height. Consequently major problems may be created in ensuring a sufficient freeboard, plotting surface runoff and maintaining water quality.

c. Plans for non-urbanized areas.
   Zoning plans for non-urbanized areas generally focus on land use. This means that in one catchment area or along one watercourse there may be several plans, all of which require a radically different method of water management. One of the clearest examples of this is where one bank is used for agriculture and the other one is a conservation area.

d. General environmental legislation.

   Much of the environmental legislation is outside the influence of the waterboards. This applies to the content of the legislation as well as the implementation and enforcement policies. As a result of this the various measures may not be coordinated. By waste water treatment the water manager may reduce the pollution of waste water. The greater the extent of the treatment undertaken by the water manager the more the quality of the surface water (function fulfilment) depends on others. Some examples of this are the phosphate reduction policy and sewer management.

## 3.2 The internal factors

These are factors which can be influenced directly by the waterboard. These concern design, structure and management. The waterboard is confronted with many questions and problems, even in this "controllable" process. Some of the most important of these are summarized below.

a. Relationships between surface water and groundwater.

   Any change to the quantitative surface water system will have quantitative and qualitative influences on the groundwater, and vice versa. This influence may be determined with geohydrological models. However, there are insufficient geohydrological data to use the models at the correct scale.

b. Target or reference situations (what is a desirable long-term ecological system?).

   Unambiguous and practical methods to determine the reference or current ecological situation are still being developed (a standard for assessing hydrological systems). The AMOEBE method included in the DNW may offer some prospects. The EEKO project, an ecological study of the Province of Overijssel, will undoubtedly be a great step forward. Verdonschot (this volume) will discuss this in greater detail.

c. Lack of knowledge of action - effect relationships.

   The influence of management actions on the ecological system is unclear and sometimes unknown. The "learn by doing" principle is often used. Even though the objectives may be known, the path to their implementation is often not better defined than a rough direction.

- Is the construction of lowered canal banks in eutrophic water to be recommended?
- What is good management (level control, maintenance methods and maintenance policy) given the specific functions?

d. Land acquisition.

Water saving designs and ecologically acceptable management generally requires the purchase of more land. Land is expensive and scarce. This almost rules out implementation outside land planning.

# 4 FURTHER PROBLEM ANALYSIS IN TWO CASES

The factors referred to which impose constraints on ecological water management in practice include the shortages of surface water and the lack of coordination between land use and water use. A practical example of both problems follows. To illustrate the water shortage, the share of water obtained by withdrawing groundwater from the groundwater storage will be given for two of the major hydrological units in Twente. A study of the western part of Twente, undertaken by the TNO Institute of Applied Geoscience, will be described by Gieske (this volume) as an example of the advances in modelling. This technique represents a major advance in forecasting and will be used increasingly to determine the consequences of changes to the hydrological system (Section 4.1). A brook system in the Oldenzaal area will be used to illustrate the lack of coordination between land use and water use (Section 4.2).

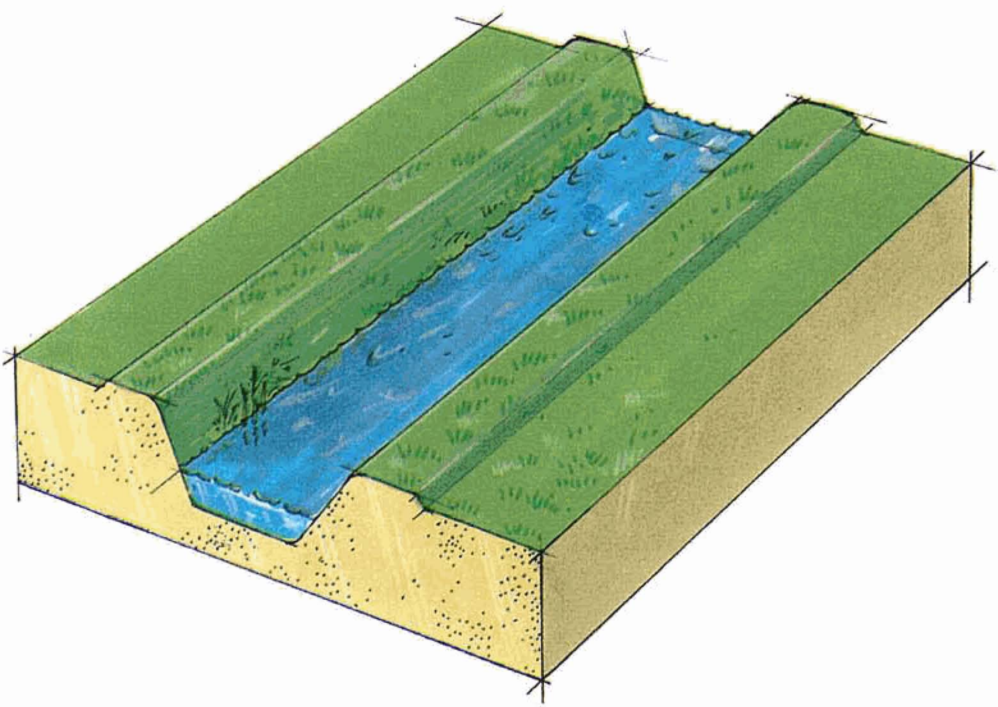
## 4.1 Groundwater withdrawal

Figure 3 illustrates the location and licensed capacity of public groundwater withdrawal points for potable water and industrial water in two major flow areas.

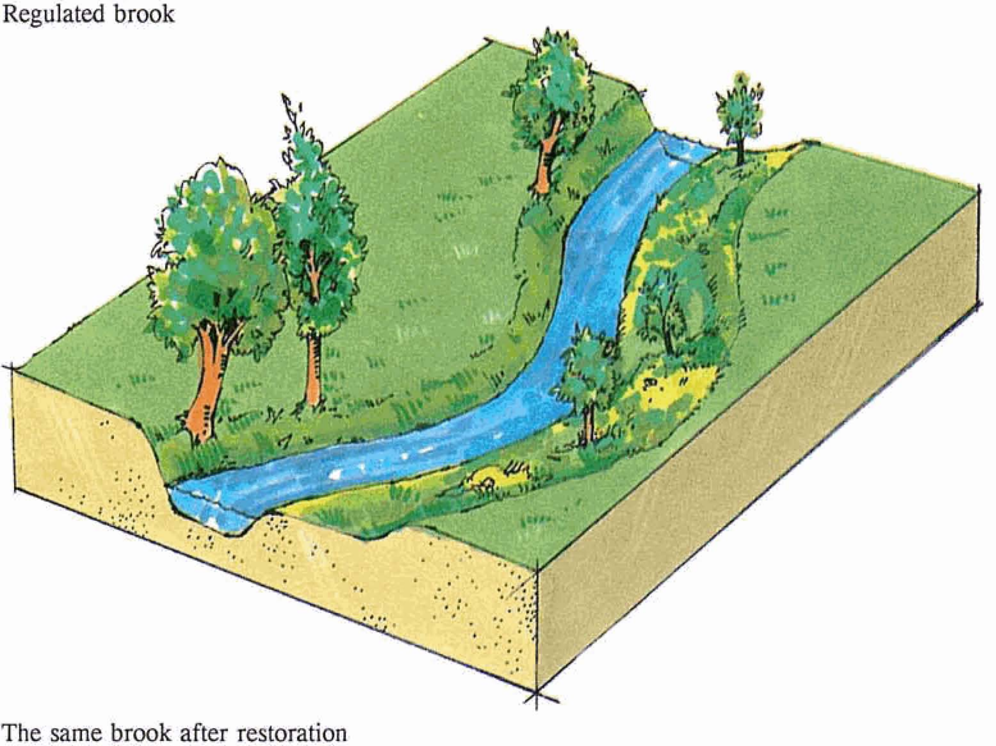
If industrial withdrawals and agricultural irrigation are also included the picture is as given in Table 1. The table shows that the groundwater recovered each year amounts to between 10 and 30% of the rainwater surplus. If this is considered per sub-catchment area the

Brook before regulation

Regulated brook



Regulated brook



The same brook after restoration

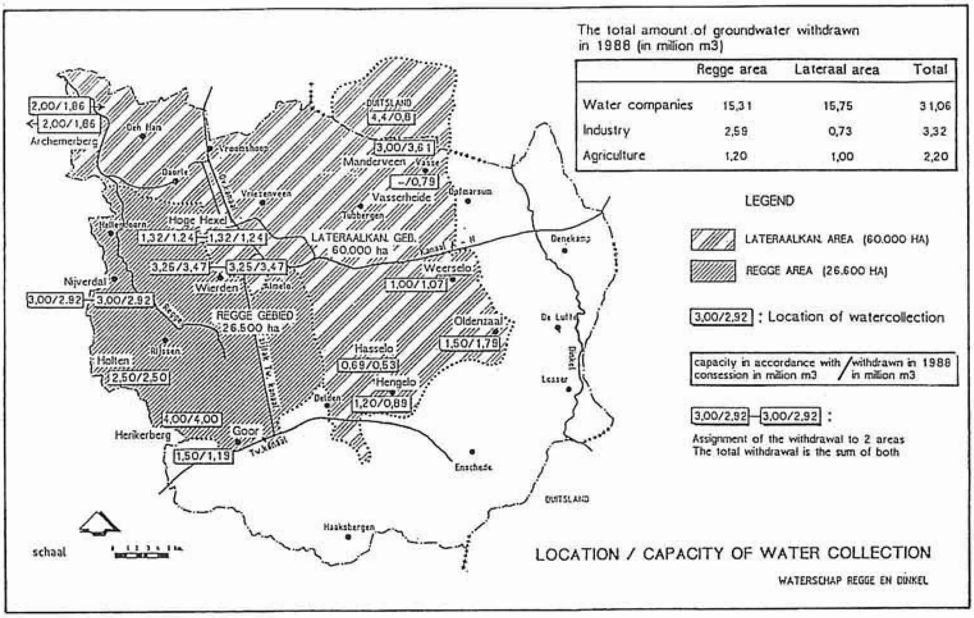



Figure 3 Location and capacity of two water collection areas in Twente

Table 1 Percentage of artificially recovered groundwater compared to the rain water surplus in 1988

| Catchment area | Regge | Lateraalkanaal |
|---|---|---|
| Size of the catchment area | 26 500 ha | 60 000 ha |
| Withdrawal for potable water production | 15.31 $10^6$ $m^3$ | 15.25 $10^6$ $m^3$ |
| Withdrawal for industrial purposes | 2.59 " | 0.73 " |
| Agricultural irrigation (groundwater) | 1.13 " *) | 0.71 " *) |
| Total (rounded) | 19.0 $10^6$ $m^3$ | 16.7 $10^6$ $m^3$ |
| Rain surplus: 250 mm | 66.0 $10^6$ $m^3$ | 150.0 $10^6$ $m^3$ |
| Percentage of groundwater recovered | 29% | 11.5% |

*) These quantities may be considerably higher in drier years

percentages may be even higher. Although this water is not lost to the water balance of the waterboard as it is eventually discharged from treatment works, it plays only a minor role in water management. The reason for this is that the discharged water is generally quickly removed from the management area by the larger watercourses which generally provide drainage all year round and which are located in other catchment areas than those in which the groundwater is extracted. The new modelling techniques which have been developed can be used to calculate the consequences of such actions.

The functions of current modelling techniques in forecasting the effects of changes to groundwater systems are described in the next paper (Gieske, this volume).

### 4.2 Differences in land and water use; the controversy between land use planning and function allocation

The controversy between land use and water use has been mentioned as one of the constraints on pursuing an acceptable ecological water management policy. In the Regional Plan for Twente (draft August 1989) the water quality is associated with soil use, according to the following model:

| Use | Zone | Water quality |
|---|---|---|
| Agriculture | I | Basic quality |
| | II | Higher than basic quality |
| | III | Ecological quality |
| Nature | IV | Natural system |
| Forest | - | Miscellaneous |

Similarly the water quality is directly influenced by the use of the adjoining land.
The use of the upper and middle sections of a potentially undisturbed watercourse in the Oldenzaal area has been defined in the regional plan (Figure 4).

| LEFT BANK LAND USE | REGIONAL PLAN USE | | RIGHT BANK LAND USE |
|---|---|---|---|
| | lg II | lg II and III | |
| Deurningen | urbanised area | urbanised area | Oldenzaal |
| | | recreation | "Het Hulsbeek" estate |
| Hengelo-Germany railway | | | |
| | lg II and III | lg II | |
| | forest | potable water | Oldenzaal pumping station |
| Twente airport | transport | transport | A1 national highway |
| clay pits | minerals | urbanised area | Oldenzaal |
| | | industry | industrial estate |
| Oldenzaal-Enschede road | | | |
| golf links | lg I and IV | lg II and III | golf links |
| | forest | forest | |
| | SOURCE Jufferbeek | | |

Figure 4 Regional Plan use of the banks of the Jufferbeek in the Oldenzaal area.

In short, there are 8 different uses on the right bank and 7 on the left bank. The municipalities generally set up an even finer structure in their zoning plans. The manager of the watercourse is therefore confronted with a situation in which it is not possible at all, or only with great effort, to implement a high ecological level.

## 5 RECOMMENDATIONS, SOLUTIONS?

Developing and maintaining a durable ecologically acceptable water system requires a thorough approach to water management. In itself this requires a change in management to implement it.

The following could be considered as possible changes to the organization of the waterboard organization:

- the organization;
- the statutory instruments (waterboard rules and regulations);
- the charging system;
- the structure of the management committee (in some cases);
- the type of watercourses;
- the management and maintenance.

Responsible integrated water management also requires that:

- the initial situation of the watercourses to be studied is known;
- the objectives have been defined;
- the feasibility of the objectives (function allocation) can be assessed.

Conditions for this include:

- extensive knowledge of the area;
- understanding of action-effect relationships;
- quality and quantity management by the same authority (highly recommended);
- greater formal control over groundwater (desirable);
- coordination between water management and planning policy.

In more concrete terms my contribution listed some practical limitations which may impede the development of a durable ecologically acceptable water system.

This concerned:

a. Groundwater withdrawal.

   A major symposium on this issue was held on May 31, 1990. It would not be useful to try to reiterate the opinions stated. However, I regard Claessens' (Rijkswaterstaat, Institute for Inland Water and Waste Water Treatment) conclusions as very valuable in general terms. One of his conclusions was that groundwater withdrawal should be moved to less vulnerable areas. Options for this can be studied with the new modelling techniques. Combinations of groundwater withdrawal and water saving measures in areas upstream should be studied. Such a study is currently being carried out in the

Saasveld/Gammelke re-allotment area in Overijssel. Another option to extend the groundwater storage may be provided by a policy in which the manager of the surface water gives greater attention to the "dry" aspects of reduced production.

The initial policy considerations in the quantity policy of the waterboard are historically the "wet" aspects of water management. The consequences of this to the groundwater levels in higher areas were only considered as an effect of the actions. Several government policy documents have clearly shifted the emphasis towards a policy to avoid drying out of areas. This policy may be implemented through the low-lying and higher areas. The attention given to the high areas is a new aspect. As a consequence of this view the waterboards will have to follow a two-track policy. In addition to the additional approach from the "wet" side (measures to lower the groundwater level), actions in higher areas (measures to raise the groundwater level) will also have to be considered to determine their effects on the water management of the brook valleys. As far as efficiency considerations are concerned it does not matter whether the increased production is obtained on the "wet" side or on the "dry" side. However, the approach through the higher areas may also have a positive effect on groundwater use other than for nature conservation and water recovery.

b. The controversy between water use and land use.
For land use planning the creation of development opportunities for a durable ecologically acceptable system will have to be used as a premise. This means that regional plans as well as municipal zoning plans will have to be adapted in many aspects. The nature and extent of the adaptations will depend on the function assigned to the watercourse.

## REFERENCES

GIESKE, J.M.J.; 1991. The effects of stresses on the groundwater flow systems in West Twente. Proc. and Inf. no. 45, CHO-TNO, Delft: 51-58 (This volume).

MINISTERIE VAN VERKEER EN WATERSTAAT; 1989. Derde Nota Waterhuishouding.

PROVINCIE OVERIJSSEL; 1989. Voorontwerp Streekplan Twente 1990.

PROVINCIE OVERIJSSEL; 1984. Waterkwaliteitsplan.

PROVINCIE OVERIJSSEL; 1988. Grondwater in Overijssel 1988.

VERDONSCHOT, P.F.M.; 1991. The web-approach: a tool in water management. Proc. and Inf. no. 45, CHO-TNO, Delft: 59-76 (This volume).

WATERSCHAP REGGE EN DINKEL; 1989. Waterbeheersplan 1989-1994, Almelo.

**Ecological Water Management in Practice** (Proceedings of the technical meeting held in Ede, The Netherlands, 3 October 1990). Proceedings and Information CHO-TNO, no. 45, 1991.

# THE EFFECTS OF STRESSES ON THE GROUNDWATER FLOW SYSTEMS IN WEST TWENTE

J.M.J. Gieske

## 1 INTRODUCTION

A hydrogeological modelling study was done in West Twente (part of the province of Overijssel) to elucidate the nature and behaviour of the groundwater flow systems so that water management in the area can integrate and balance the various water uses (drinking water, environment, agriculture). The study was done by the TNO Institute of Applied Geoscience and supported by the Province of Overijssel, the waterboard Regge and Dinkel, the National Forest Service in the Netherlands and the Watersupply Company Overijssel Ltd.

The model code Modflow (McDonald, et al, 1983) was used to calculate groundwater heads; FLOSA-FD (Zijl, 1988) was then used to calculate groundwater flow paths, residence times and infiltration and exfiltration areas. Maps of groundwater flow systems were prepared, indicating the infiltration and exfiltration areas of the groundwater flow systems and the direction of groundwater flow.

It was important to understand the effect of stresses on the groundwater flow systems. The major stresses in the study area are abstraction of groundwater and changes in surface water levels in land re-allotment areas; to ascertain their impact the models were run for five steady state situations: a typical winter situation, a winter situation with no groundwater abstraction, a winter situation with no land re-allotment, a "natural" winter situation with no major human interferance and a typical summer situation. Given the available space, this article will not cover the "natural" situation and the summer situation; for this, see the study report (Gieske, 1989).

## 2 CHARACTERISTICS OF THE STUDY AREA

The study area is some 400 $km^2$ and is crossed by the Regge river. The Salland lateral moraine lies to the west of the Regge river, to the east fluvial, fluvio-glacial and aeolian sand deposits occur, and some low lateral moraines.

The aquifer is formed mainly by deposits from the Harderwijk, Enschede and Urk Formations. The impermeable base dips from approximately 10 to 15 m below ground level in the south-west to some 100 to 150 m in the north-east. Figure 1 shows the study area, plus locations of groundwater abstraction for drinking water and land re-allotment areas.

## 3 MODEL STRUCTURE

The structure of the Modflow model can be broadly described as follows. The grid blocks which comprise the model are 500 by 500 m. The model is 33 blocks (16.5 km) wide and 48 blocks (24 km) long. It contains four grid layers of varying thickness. The transmissivity values of the aquifers and resistance values of the semi-permeable layers were obtained from the provincial data base. The surface water data (water level, bottom elevation and wetted perimeter) were supplied by the waterboard Regge and Dinkel. Data on depth and amount of groundwater abstraction was taken from the VEWIN report (1986). Boundary heads were derived from the isohypse maps for the 1983 winter situation from the report "Inventarisatie Grondwatergegevens in de Provincie Overijssel" [Inventory of Groundwater data in the Province of Overijssel] (Haak, 1985). The model was calibrated with the isohypse map referred to above.

The Flosa-FD model is composed of grid blocks of 500 by 500 m with a thickness of 5 m. It comprises 30 grid layers. Permeability values were derived from hydrogeological maps

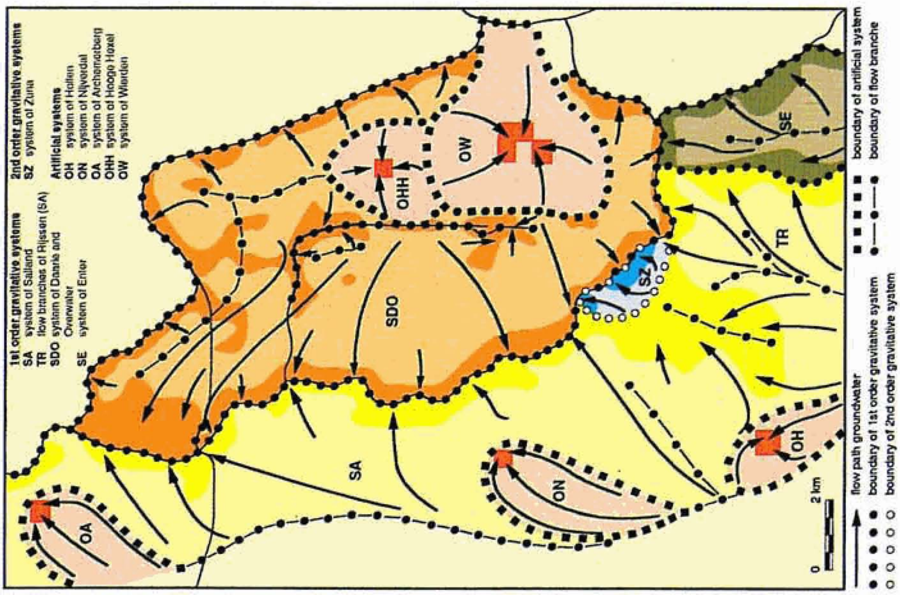



Figure 2 Groundwater flow systems map of the "present" winter situation

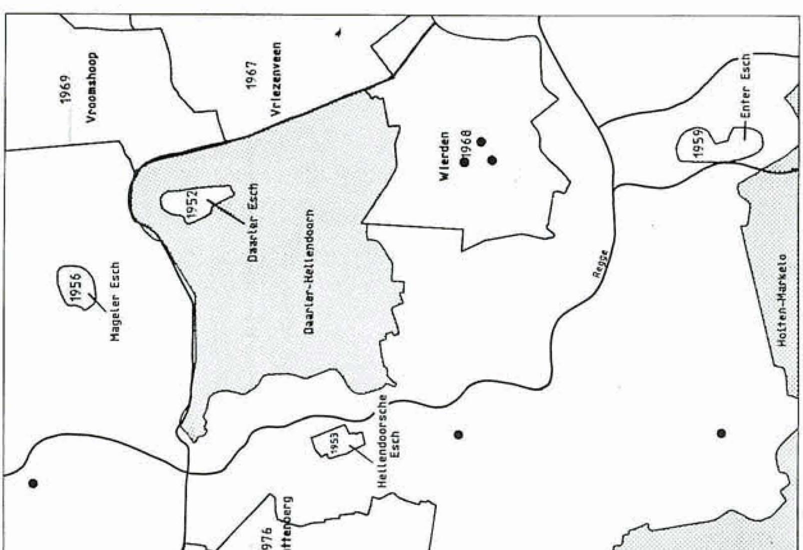



Figure 1 Study area West Twente

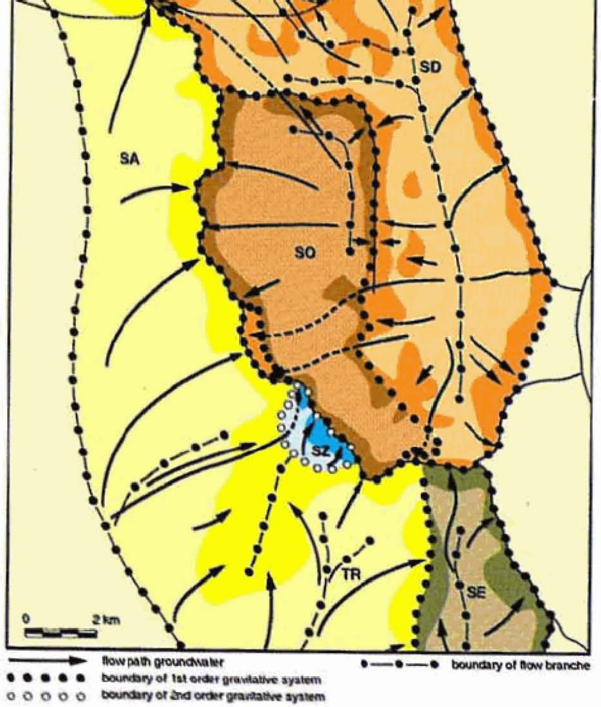



Figure 3 Groundwater flow systems map of winter situation without abstractions

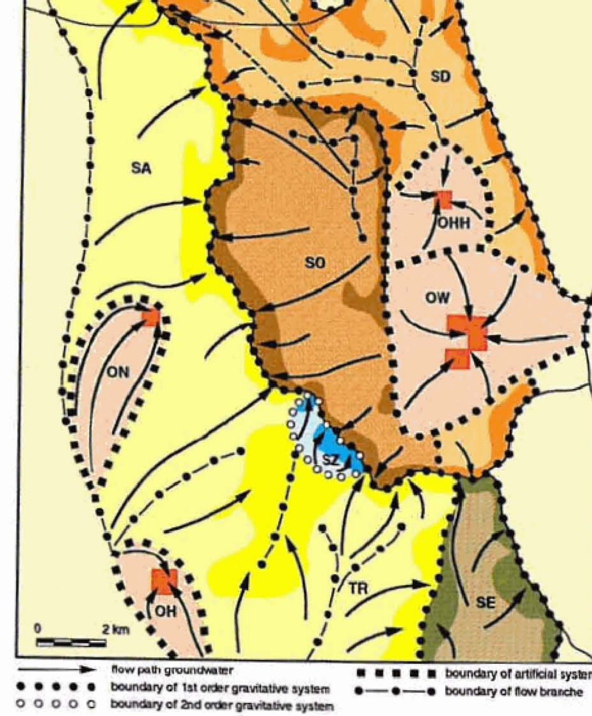



Figure 4 Groundwater flow systems map of winter situation without re-allotment

and profiles from the Inventory report mentioned above (Haak, 1985), as well as from draft geological maps and profiles (RGD, 1988). The Flosa-input was kept as consistent with the Modflow-input as possible. Boundary heads for the top and sides of the model were derived from the Modflow model. The mass balance was checked and showed a deviation of 5 %.

# 4 RESULTS

## 4.1 "Present" winter situation

Streamlines were calculated from all grid points on the upper plane of the Flosa-FD model for the winter situation of 1983. The groundwater flow systems were mapped by drawing a boundary around the seepage areas related to an infiltration area (Engelen, 1986). This map is presented in Figure 2. To keep the map readable only a few streamlines have been indicated for each flow system. Seepage areas are represented in a darker shade, infiltration areas in a lighter shade.

Some of the groundwater flow systems are gravity-induced (e.g. the system of the Salland lateral moraine) and some are "artificial" systems, driven by the abstraction of groundwater (e.g. the Wierden system). The boundary of the gravity-induced systems is indicated with circles, that of the artificial systems by squares. The groundwater flow systems were named after locations in the infiltration area. Parts within the groundwater flow system with different flow directions are separated by lines with circles.

Generally, the residence times in the Salland system do not greatly exceed 100 years. The residence times in the Overwater system are limited to 100 to 200 years.

## 4.2 Winter situation with no abstractions

In a situation of zero abstraction the groundwater flow pattern changes most significantly in the eastern part of the area, as can be seen in Figure 3. Here the original groundwater flow systems recover and seepage areas return, particularly south-east of Wierden. The flow pattern in the Salland system also recovers and the groundwater divide shifts slightly eastwards. The residence times in the southern part of the Daarle groundwater system do not exceed 100 years. Some flow lines in this system extend to the Regge and have a residence time of some 1000 years. The difference between the groundwater levels in this situation and the situation with abstractions is shown in Figure 5.

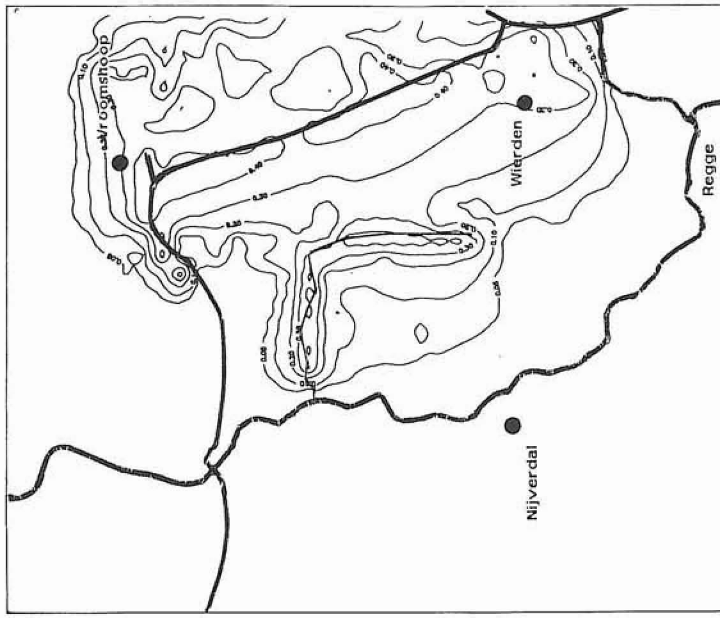
### 4.3 Winter situation with no land re-allotment

To simulate a winter situation with no land re-allotment the surface water levels in the re-allotment areas were raised by 0.5 m. Although in reality the decrease in surface water level during re-allotment was more varied, 0.5 m is a reasonable approximation (personal communication: Overijssel Land Development Service). Figure 4 shows that this increase has little effect on the regional groundwater flow pattern. The Daarle and Overwater systems (Figure 2), however, can no longer be distinguished from each other because the watercourse between the systems no longer divides them. The residence times are similar to those in the "present" situation. The difference between the groundwater levels in the situation without re-allotment and the "present" winter situation is shown in Figure 6.

## 5 CONCLUSION

The calculations clearly show that the abstractions near Wierden greatly influence the groundwater flow (compare Figures 2 and 3). The abstractions within the Salland system have less impact. The abstractions affect the groundwater levels over large parts of the area (Figure 5).

The fall in surface water levels in the re-allotment areas hardly affects the regional pattern of groundwater flow (compare Figures 2 and 4). It is important to note that the effect on the local patterns of groundwater flow is expected to be major, but could not be calculated because the model grid is too coarse. Obviously the groundwater levels in the re-allotment areas fell (Figure 6).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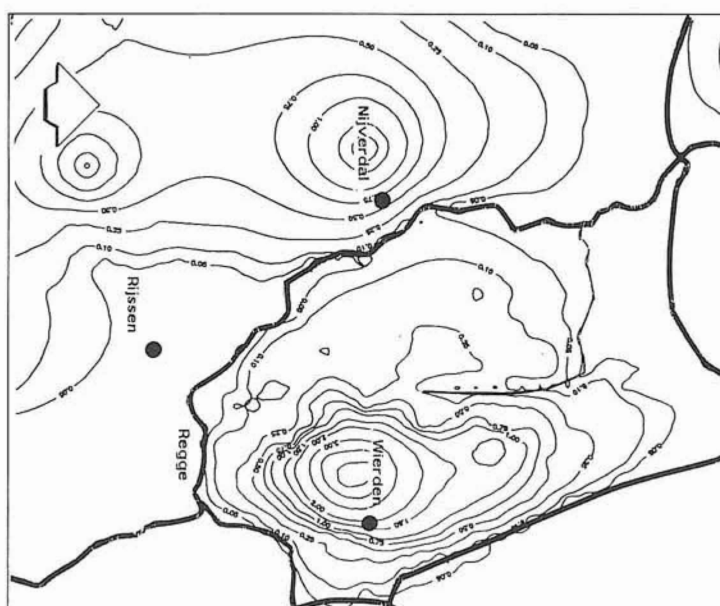
Wierden
Regge
Nijverdal


Nijverdal
Rijssen
Regge
Wierden

## REFERENCES

ENGELEN, G.B.; 1986. Water systems, methodology and definitions, in: Engelen, G.B. and G.P. Jones (Ed.). Developments in the analysis of groundwater flow systems, IAHS Publ. 163, pp. 67-107.

GIESKE, J.M.J.; 1989. Effecten van ingrepen op de grondwatersystemen in het Reggedal, rapportnr. OS 90-27-B. Dienst Grondwaterverkenning TNO, Delft/Oosterwolde.

HAAK, A.M.; 1985. Inventarisatie grondwatergegevens in de provincie Overijssel, rapport nr. OS 85-06. Dienst Grondwaterverkenning TNO, Delft/Oosterwolde.

McDONALD, M.G. and A.W. HARBAUGH; 1983. A modular three-dimensional finite-difference groundwater flow model US Geological Survey.

RIJKS GEOLOGISCHE DIENST; 1988. Korte beschrijving van de geologische kaart 28 Oost/29, briefnr. 881495.

VEWIN; 1986. Provinciaal overzicht win- en produktiemiddelen, provincies Overijssel, Gelderland en Flevoland.

ZIJL, W.; 1988. Three-dimensional flow systems analysis: basis equations and numerical modelling, rapportnr. OS 88-12. Dienst Grondwaterverkenning TNO, Delft/ Oosterwolde.

**Ecological Water Management in Practice** (Proceedings of the technical meeting held in Ede, The Netherlands, 3 October 1990). Proceedings and Information CHO-TNO, no. 45, 1991.

# THE WEB-APPROACH: A TOOL IN WATER MANAGEMENT

P.F.M. Verdonschot

## ABSTRACT

A study to gather research priorities for ecological water management showed that there is a need for knowledge of reference frameworks, of disturbance-effect relations and of assessment systems. It is argued that the pursued stage of a water should not be defined in terms of a static reference. But a pursued stage should be described in terms of potential directions of ecological development. This asks for a web-approach; a web of more and less described stages in the developmental series of water systems, and their mutual interrelations. This web can serve as a reference framework. The difference is shown between the measurement of a water and its valuation. The valuation of a water and thus the application of an assessment system can be directed towards one (complex of) environmental factor(s) or towards the whole ecosystem. Before this, the objectives of measurement and valuation should be made clear. The assessment of the whole ecosystem is best be met by using framework of developmental stages of ecosystems: the web-approach. It is expected that in future ecological research will be directed towards prediction. It therefore becomes necessary to indicate the potential capacities of present waters. Again, the web-approach offers possibilities. Knowledge of disturbance-effect relations can be of great support.

## 1 INTRODUCTION

This article deals with the questions of ecologists employed by Dutch water authorities as to the role of ecology in water management. Which ecological knowledge is lacking and what can be done about it? Only some major issues will be discussed in general, as it is impossible to deal with each question in detail. De Vries et al. (1989) made an inventory of gaps in knowledge of ecologists employed by some Dutch water authorities. They made a priority list of research that should be done to serve and support ecological water management. They concluded that on the one hand aquatic ecologists in research have knowledge that is not known by their colleagues in water management, and on the other hand ecologists practising water management ask for knowledge which is still missing. De Vries et al. (1989) summarized the following research priorities necessary:

- to get more insight in the ecological functioning of different types of aquatic ecosystems and in the ways to steer systems through a directed form of management (the reference framework);
- to develop quick and simple methods for the characterization and assessment of water systems (the assessment systems);
- to gather more knowledge of the disturbance-effect relation in especially smaller water types, and
- to exchange and distribute existing knowledge by means of publications, handbooks, consultative bodies and courses. This symposium issue is an example of the last point. This point will not be discussed.

When an ecologist tries to initiate or affect the water management policy, he will often follow (part of) the next working procedure:

1. to measure: the measurement of abiotic and biotic variables;
2. to compare: the comparison of the measurement with a reference framework;
3. to choose: the choice of the desired solution;
4. to manage: the execution of the measures;
5. to evaluate: the evaluation of the results.

In Table 1 the above given research priorities and working procedure are compared.

Table 1 Comparison of research priorities and the ecologists' procedure.

| | measure | compare | choose | manage | evaluate |
|---|---|---|---|---|---|
| reference framework | + | + | + | (+) | (+) |
| disturbance-effect relation | | | | + | |
| assessment system | | | | | + |

It appears that a reference framework is necessary for measurement, comparison, and choice. Knowledge of disturbance-effect relations is necessary for management and an assessment system is necessary for evaluation. But both management and evaluation can also be supported by knowledge of a reference framework.

## 2 THE REFERENCE FRAMEWORK

According to Warren et al. (1979) only the structure of a community can be measured, its capacity and functioning can only be represented indirectly and incompletely. This would in general limit the applicability of functional parameters. At the moment structural characteristics of ecosystems, like species composition and related parameters, are applied in the daily practice of Dutch water management. Among others, Verdonschot (1983) and CUWVO (1989) concluded that an ecological classification of surface waters, based on structural parameters, is necessary for an ecologically-orientated water management. Such a classification can be the basis of a reference framework. What is meant by the term reference?

In water management one often speaks about a desired stage of a water, a pursued stage or the ('natural') reference stage. These all are subjective conceptions and each concept often has different definitions. Higler and Verdonschot (1990) distinguished four definitions of the reference, namely:

- the 'former' or 'original' stage known from literature;
- the 'natural' stage defined as the conditions which develop under the given climatological, geographical, geomorphological and biogeographical circumstances;

- the present 'optimal' stage which actually can be measured;
- the 'potential optimal' stage, taking the present and future conditions in consideration.

These definitions of the reference stage are often used indifferently. For example, the ecological 'optimal' stage is often described in terms of the 'natural' conditions based on information of the past. In fact, one tries to compare the actual stage of a water with that of another, preferably anthropogenically undisturbed, water and defines the latter as optimal (the reference stage). But each ecological system, in general, represents a system that functions under the given conditions. This does not mean that each ecosystem thus represents an ecologically optimal stage and thus has an equal natural value. The ecologically optimal stage can be defined as the condition whereby an ecosystem under the given climatological, geomorphological and geological conditions functions self-maintaining. Often this ecologically optimal stage is again not the most pursued stage. For example, think of succession series. If this optimal stage would be the endpoint in succession, many stagnant waters would finally be terrestrial systems. This conflicts with the objectives of water management. It can be concluded that the meaning of many terms, like reference and optimal, is anthropogenic and depends on the pursued objectives. Therefore, some arguments will be given below that, in general, plea against a concrete definition of the reference stage. It concerns aspects of naturalness, information from the past, variability of the optimum and unfamiliarity with future circumstances.

## 2.1 Naturalness

What is natural in an aquatic ecosystem? Many stagnant waters (ditches, canals, sand- and peat-pits) are dug by men. Part of them would gradually be filled and become terrestrial without human interference. Their natural stage in fact is a terrestrial one. Some stagnant waters, like acid moorland pools and deep, meso- and oligotrophic lakes, are stable aquatic systems and will not or only very slowly become terrestrial. Naturalness in the sense of the endpoint of a succession (a climax) cannot be the only criterion to describe a reference stage. Although, it is possible to choose a well developed stage out of the succession as a stage to be pursued. Naturalness and succession are conceptions often used indifferently. It is therefore better to define the term reference as the ecological optimal developmental stage. In many stagnant waters, this ecological optimal developmental stage does not represent a dynamic balance but can only be described in terms of ranges of relevant environmental parameters under which circumstances certain species combinations occur. Streaming waters are continuously stressed by the master factor current. The current causes a dynamic or metastable balance. On the other hand their ecological optimal developmental stage is represented by the endpoint of succession.

### 2.2 Information from the past

The reference stage in running waters is often based on former data. This concerns, for example, information from the period before 1930 (Ministerie van Verkeer & Waterstaat, 1989) or paleolimnological results. The former stages are often called natural. But these data were at that time also subject to human interferences or different environmental circumstances (Van Dam, 1987). A former stage could have been more diverse or could have had a more complex structure than the present stage, but can still be unnatural due to the absence of bank vegetation, differences in morphology, and so on. So, information from the past cannot be the only criterion to describe the reference stage, but one can use former data to support this description.

### 2.3 Variability of the optimum

The ecological optimal stage differs from one water to another. In fact each fully developed water has an unique character. This great diversity hampers an exact description of the reference stage. The reference should be described in a less exact and flexible manner.

### 2.4 Unfamiliarity with future circumstances

It can be assumed that future combinations of chemical and physical parameters will differ from the present ones due to future developments in society. New kinds of human activities will lead to these new environmental circumstances. These new environmental circumstances will induce new species combinations. This lessens the reliability of the use of present or former information on species combinations. Even a reduction of present kinds of human disturbances and restoration of former conditions does not automatically imply the return of former communities. It often concerns irreversible processes. But a taxon inhabits a more or less known structural and functional niche. A taxon-niche approach gives better opportunities to manage future situations.

The argumentation above points out that one should not try to define one stage as a desired static point on a reference scale. Furthermore, it appears to be impossible to give objective criteria for the definition of this static point. Therefore, the objective should not imply a strictly defined stage but it should indicate the direction towards an ecologically optimal development. This directional process is described as ecosystem development (Verdonschot, 1983). The degree of ecosystem development informs about the actual stage of the aquatic ecosystem and its potential development or capacity (Figure 1). For water management the choices which direct this development are essential.

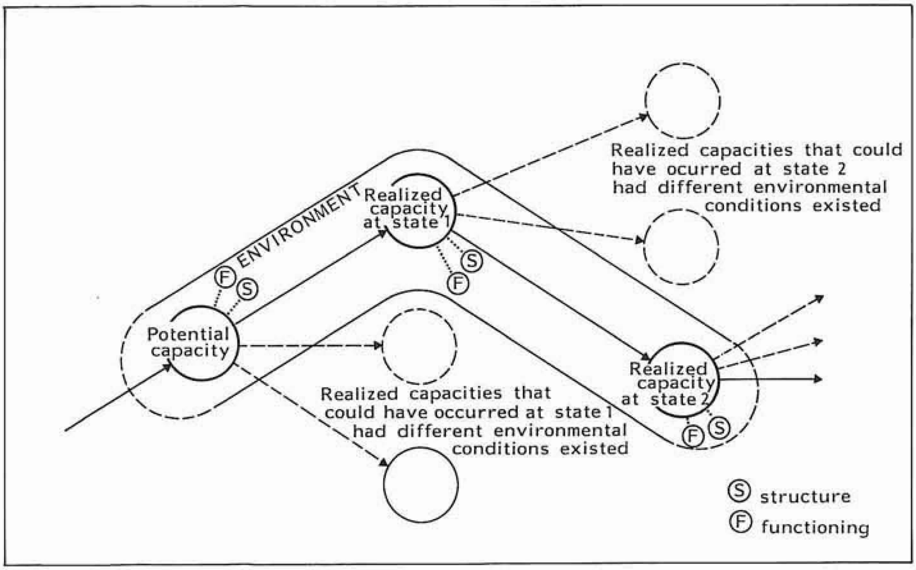



Figure 1 The capacity of a biological community. Each biological community possesses a realized and a potential capacity. The potential capacity is the predetermination of all possible states and structures which can evolve from the present system. The interaction of system capacity and the state of the environment determine the system structure realized at any moment (the realized capacity). If the environment at any time had been different, another sequence of capacities actually realized would have been the result (adapted from Warren et al., 1979).

## 3 THE WEB-APPROACH

The optimum in ecosystem development as the endpoint in a succession is illustrated in Figure 2-A. It is already argued that one should not try to describe such a point (reference stage R in Figure 2-A). One should only indicate potential directions of ecosystem development. This means that no static point is defined but different more or less defined stages and that different directions of potential development from the actual stage are indicated (Figure 2-B). Figure 2-B illustrates a web of such more or less defined stages and their interrelations. Such a web can serve as a reference framework.

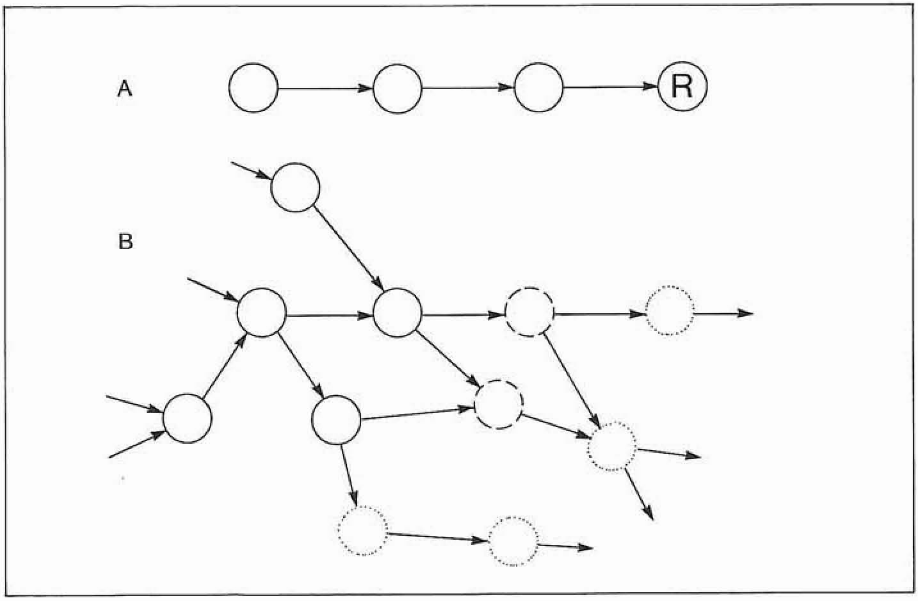



Figure 2 Reference systems: A. a reference system with a fixed endpoint R and a singular series. B. a reference system with more developmental stages in different directions (a web) and more or less well defined stages (open and dotted circles).

The stage and the potential directions in ecosystem development of a water depend on the intrinsic character of that specific water. For a description of this intrinsic character it is important to get:

- knowledge of the actual condition (the actual ecosystem development) in terms of abiotic and biotic parameters and of abiotic master factors;
- knowledge of the potential ecological developmental series (these can be deduced from a

web of water types);

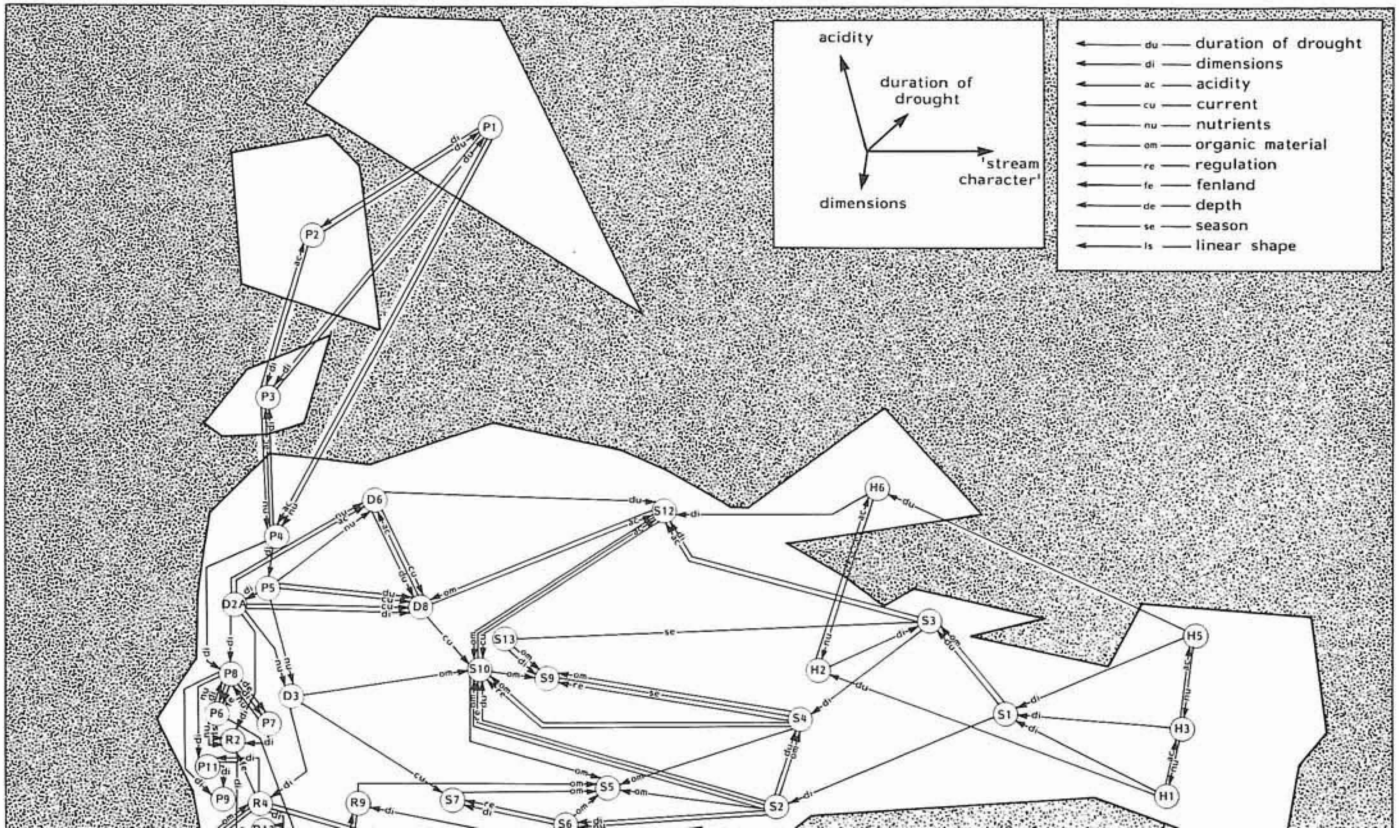
- knowledge of the former conditions and their development towards the actual stage (in other words knowledge of the actual development of former potentials), and
- knowledge of ecological principles and processes (like succession, stability, diversity, stress, and resilience).

To describe the intrinsic character of a water a list of abiotic conditions is even more important than a list of rare and/or characteristic species.

## 3.1 The EKOO-project

An example of the web-approach is illustrated by the results of the EKOO-project. EKOO is the abbreviation of "Ecological characterization of surface waters in the province of Overijssel (The Netherlands)" (Provinciale Waterstaat Overijssel, 1983; Verdonschot, 1990). For this study, in total 664 sites, including all major environmental variables and their combinations relevant to this region, were sampled. Macrofauna composition was chosen as a basic parameter. About 70 variables, that were considered physically, chemically or biologically relevant, were measured at each sampling site. All data were processed together to obtain an ecological water topology. Multivariate analysis techniques are appropriate in data analysis for topological purposes. Different multivariate analysis techniques were used to derive and describe site groups in terms of corresponding taxon composition and mean environmental conditions. The methodology is called cenotypology (ceno- is derived from the Greek word koinos = common), and offers the possibility to analyse abiotic and biotic information at the same time. Finally, 42 site groups, termed cenotypes, were distinguished. The mutual relations between the cenotypes were shown in a web (Figure 3).

The four most important abiotic parameters are current, acidity, duration of drought, and dimension. Furthermore, the nutrient content and/or load of organic material differed between related cenotypes. The 'natural' abiotic parameters all are more or less influenced by human activities. For example, it appeared that regulation and pollution affected the biotic features of most rivers, middle and lower reaches of streams, ditches and medium-sized lakes in such way that they all became to look alike. Only some


acidity
duration of drought
'stream character'
dimensions
du — duration of drought
di — dimensions
ac — acidity
cu — current
nu — nutrients
om — organic material
re — regulation
fe — fenland
de — depth
se — season
ls — linear shape

representatives of these waters still have their intrinsic biotic features.

The web of cenotypes offers a basis that can be used for the daily practice of regional water management. The web supports the development of water quality objectives and standards, the methods to monitor and assess waters, it indicates the potentials of waters and offers information for the management and restoration of waters. The web of cenotypes functions as the reference framework for the province of Overijssel and is an example of the web-approach.

## 4 ASSESSMENT SYSTEMS

To determine if an actual condition agrees with a pursued condition, it is necessary to measure the actual condition and compare the results with a reference framework. If this comparison is made by means of an arithmetical technique, the reference framework is defined as a reference system. The actual condition can only be valuated when the reference system is accompanied by a valuation scale.

So, there is a distinct difference between measurement and comparison versus valuation.

The importance of this difference is also illustrated by the following examples:

a. Firstly the actual condition of a peat-pit surrounded by woodland (with a natural but high organic content) and a peat-pit in an agricultural surrounding is measured. Subsequently both measurements are valuated according to the water quality score system after Caspers and Karbe (Hovenkamp et al., 1982). Both peat-pits score equally high. So, the valuation related to the water quality score system indicates that both peat-pits are equal with respect to water quality. But the environmental circumstances differ; they are natural for the woodland peat-pit and anthropogenic for the agricultural peat-pit. From an ecological point of view the valuation of both peat-pits should be different. Thus, an equal condition and an equal system score should not always automatically imply an equal valuation.
b. Firstly the actual condition of a lowland stream in the region of Salland and a lowland stream in the region of Twente is measured. Subsequently both measurements are

valuated according to the stream-index system (Gardeniers and Tolkamp, 1976). For the Salland stream a lower score is calculated than for the Twente stream. The valuation related to the stream-index system indicates that the Salland stream is a less valuable stream with respect to the factor current than the Twente stream. But the natural fall in the Salland region is much less than that in the Twente region. Both streams can therefore be ecologically best developed. Thus, a different condition should not always imply a different valuation.

c. Firstly the actual condition of a lowland stream on a hill-ridge and a lowland stream in a more flattened region is measured. Subsequently both measurements are valuated according to the water quality score system (K-index; Gardeniers and Tolkamp, 1976). The hill-ridge stream scores higher. The valuation related to the K-index system indicates that the hill-ridge stream is less organically polluted. But the natural fall of both streams differs and, therefore, both can be ecologically equally developed. A different condition and a different score should not always imply a different valuation. Furthermore, the problem of the use of an index related to only one environmental factor (in the example organic material) in different water types is illustrated.

These three examples show that measurement of the actual condition and comparison with an index should be separated from the valuation.

The occurrence of taxa is, in general, determined by the complex of abiotic and biotic variables present. Many assessment systems, like the K-index or the Saprobic system, are limited to the relation between the taxa included in the index and the environmental factors relevant for these taxa. Most pollution indices try to indicate the extent of organic pollution of the system. But most of the included taxa do not respond to the amount of organic material only but also respond to other environmental conditions. Taxa, even, do not always respond in the same way to organic pollution. For the assessment one should distinguish the assessment of one (complex of) environmental factor(s) and the assessment of a whole ecosystem. The assessment of a whole system should not be limited to the component water (Figure 4-A), nor to the waterbody (Figure 4-B), but should imply all related components (bottom, banks, and so on; Figure 4-C). The choice of methods to measure, compare and assess depends on the above given ideas and objectives.

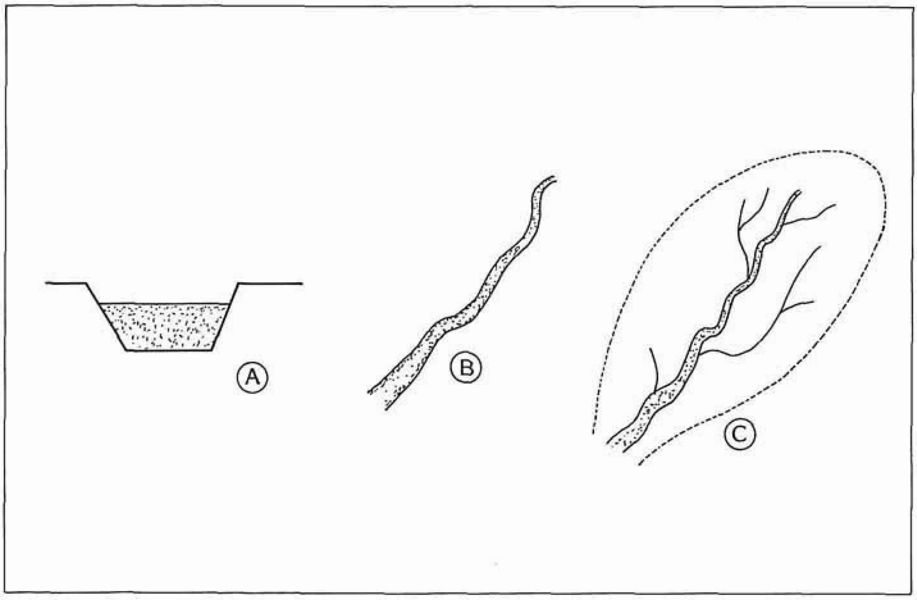



Figure 4 Three different uses of the term water quality. A: for the component water. B: for the waterbody. C. for the watershed or catchment area.

Ecological water quality assessment gives a valuation of the quality of a surface water based on ecological conditions. In general, each valuation is subjective. But application of a valuation scale is possible when all participants agree on the scale which on its turn should be related to a reference system (for example, the range of an index or a web of water types) which is based on ecological parameters. The attachment of values to the reference system is subjective but application of ecological principles can be of great support. Most problems arising from the application of assessment systems are caused by an inaccurate relation between valuation scale and reference system. A correct assessment always depends on the objectives formulated for the water under study, the criteria used for formulating the valuation scale and the suitability of the reference system. The objectives as well as the questions on the appropriate management for each water will differ and, therefore, different valuation scales, even related to one reference system, will be necessary.

As the ecosystem can only be measured in terms of structural parameters it shall be clear that a reference and assessment system should be based on structural features. The

Brook the Beerze (left) and regulation works (right)

The Eendenven (fen)

Regulated brook in winter

Brook the Geul in Southern Limburg

application of both systems can be directed towards abiotic and biotic factors. Biotic factors often typify the stage which should be valuated. Abiotic factors are the key for management to direct pursued stages. Although a topology of waters can serve as a reference framework, this does not mean that for each water type a specific assessment system should be developed. This depends on the question of which variables of the system must be valuated.

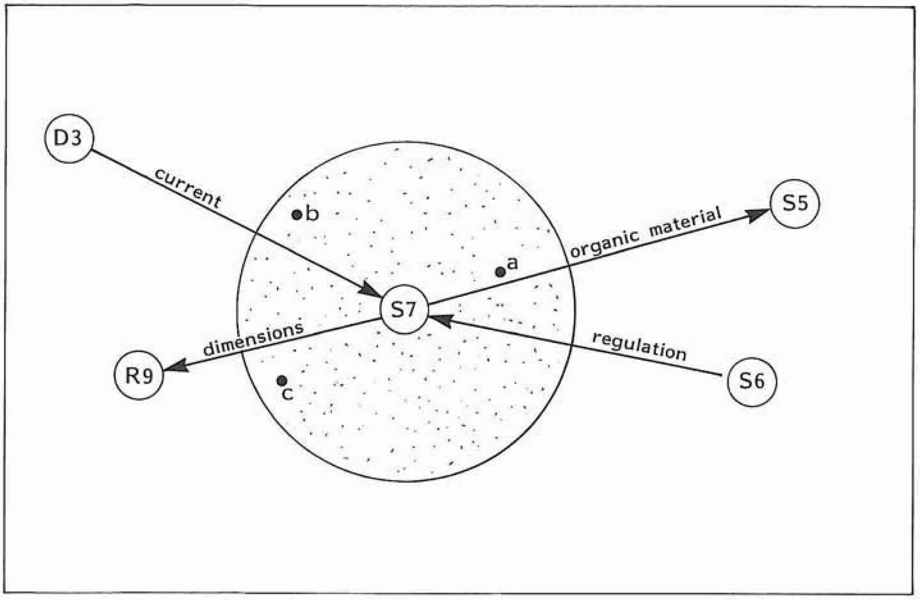



Figure 5 An example of the assessment of the whole ecosystem by means of ordination. The figure shows an ordination diagram in which five cenotypes (S5, S6, S7, D3 and R9) are projected. This projection corresponds with Figure 3. Three new sampling sites (a, b and c) are included in the analysis as passive samples. Passive samples do not influence the original position of all other sites in the analysis. All three new sampling sites belong to the cenotype S7 (dotted area). From the projection of site a can be concluded that this site has a higher organic matter content; management directed towards reduction of the organic matter content implies an improvement of site a in the direction of cenotype S6. Site b appears to be strongly channelized and stream velocity is reduced; this site looks like the ditches of cenotype D3. A management directed towards stream restoration will imply a development of site b towards cenotype S6. Site c is large and more eutrophicated than cenotype R9, a reduction of eutrophication would imply a development towards the latter cenotype.

If indicator species for such variables occur in more water types, they can be used for all of them. So, there is a clear difference between the valuation of one (complex of) factor(s) or the valuation of a whole system; both dependent on the pursued objectives. An example of the use of a reference system to assess the whole ecosystem is given in Figure 5. Furthermore, the valuation depends on biogeographical and biotypological differences which implies that assessment systems and water types can only be applied at a regional scale.

## 5 THE DISTURBANCE-EFFECT RELATIONS

There is only a limited knowledge of the specific effects of certain forms of water management on ecosystems. The specific effects on abiotic variables, important for a system ecology, are only fragmentarily known; knowledge of the effects on the biotic interactions fully lacks. With sufficient knowledge of the environmental circumstances, under which communities persist, their structure can be determined and predictions can be made on the effects of changes in the environment on the ecosystems and the community. One of the main issues of ecological research will therefore be directed towards prediction. Hereby, the potential developments of an ecosystem should be outlined. The ecological knowledge on this field is limited. Still, some suggestions can be made.

A disturbance of a water mostly implies a primary change in abiotic conditions. Even a change in biotic conditions (like the re-introduction or removal of fish species) needs a change of abiotic conditions to be fruitful in the long term. Therefore, a description of the future abiotic environment is necessary as a basis to predict ecological changes. This description should not only include ranges of master factors but also draw in outline on the one hand the habitat structures and on the other hand the entire catchment area. Even if specific biotic features are pursued, the above outline should be given. These abiotic features should all be part of a management plan.

The web-approach already dealt with the possibilities to support the prediction of future conditions. The following aspects can be included.

Firstly, it is possible to use actual conditions to extract potential developments of the ecosystem. The actual condition offers not only the typifying and common taxa but also a list of incidental taxa. These incidental taxa could have been occurred coincidentally but could also be indicative for potential capacities. These are important for future development.

Secondly, knowledge of waters obtained in other regions which are comparable to the region under study can be used. It is possible that this comparable region contains less disturbed waters. This can support a pursued form of management. Other regions can also serve as refugia; taxa already disappeared from the studied region can then more easily re-colonize, a biogeographical condition.

When the pursued development is formulated, the abiotic and/or biotic environment can be indicated by means of a species list and an environmental description. Furthermore, the necessary measures to reach the pursued 'stage' should be formulated. An interactive process of future water system indicating future habitats and future habitats indicating future taxa or vice versa leads towards the pursued hypothetical stage. This stage can only be formulated in qualitative terms (a small step in future), is directed on one specific water (local scale) and includes a relatively short developmental time (1 to 5 years). It is necessary to monitor and evaluate the effects of the measures taken to reach the pursued stage. The evaluation should include the positive and negative effects with regard to the hypotheses (the pursued stage). Naturally, all other observations should be included in the evaluation. The valuation of the result can only be made after the evaluation.

The results strongly affect the methods of valuation due to the often limited monitoring programs. Some methods of presentation are:

- a representation of the number of kilometres of water course or the increase in the area of water in which the pursued development is observed;
- a (procentual) representation of the increase in desired taxa, including new not predicted taxa;
- a representation of numbers or area of desired habitats despite the fact of realized recolonization.

## REFERENCES

CUWVO; 1988. Ecologische kwaliteitsdoelstellingen voor Nederlandse oppervlaktewateren. Coördinatiecommissie Uitvoering Wet Verontreiniging Oppervlaktewateren. 154 pp.

DE VRIES, I., BAAN, P.F.A., HIGLER, L.W.G. and VERDONSCHOT, P.F.M.; 1989. Ecologische aspecten van integraal waterbeheer. Programmeringsstudie. Raad voor het Milieu- en Natuuronderzoek, Rijswijk. 77 pp.

HIGLER, L.W.G. and VERDONSCHOT, P.F.M.; 1990. Ökologische Bewertung von Fliessgewassern in den Niederlanden. Limnologie Aktuell. In press.

HOVENKAMP-OBBEMA, I.R.M., KLAPWIJK, S.P. and LANDMAN, J.E.F.; 1982. Biologische beoordeling van de waterkwaliteit in Noord- en Zuid-Holland. $H_2O$ 15: 406-412.

MINISTERIE VAN VERKEER EN WATERSTAAT; 1989. Derde Nota Waterhuishouding. Staatsuitgeverij, 's-Gravenhage. 297 pp.

PROVINCIALE WATERSTAAT IN OVERIJSSEL; 1983. Ecologische karakterisering van oppervlaktewateren in Overijssel. Zwolle. 59 pp.

GARDENIERS, J.J.P. and TOLKAMP, H.H.; 1976. Hydrobiologische kartering, waardering en schade aan de beekfauna in Achterhoekse beken. In: Nes, T. van de (ed.); Modelonderzoek '71-'74. Comm. Bestud. Waterhuish. Gld. 26-29, 106-114, 294-296.

VAN DAM, H.; 1987. Acidification of moorland pools: a process in time. Thesis, Wageningen. 175 pp.

VERDONSCHOT, P.F.M.; 1983. Ecologische karakterisering van oppervlaktewateren in Overijssel. $H_2O$ 16: 574-579.

VERDONSCHOT, P.F.M.; 1990. Ecological characterization of surface waters in the province of Overijssel (The Netherlands). Thesis, Wageningen. 255 pp.

VERDONSCHOT, P.F.M.; 1990. Ecologische karakterisering van oppervlaktewateren in Overijssel: Het netwerk van cenotypen als instrument voor ecologisch beheer, inrichting en beoordeling van oppervlaktewateren. Provincie Overijssel, Zwolle. Rijksinstituut voor Natuurbeheer, Leersum. In press.

WARREN, C.E., ALLEN, M. and HAEFNER, J.W.; 1979. Conceptual frameworks and the philosophical foundations of general living systems theory. Behavioral Sc. 24: 296-310.

**Ecological Water Management in Practice** (Proceedings of the technical meeting held in Ede, The Netherlands, 3 October 1990). Proceedings and Information CHO-TNO, no. 45, 1991.

# ECOLOGICAL WATER MANAGEMENT AND POLICY PLANNING

K.J. Provoost

## ABSTRACT

In this article it has been established that over the past decade real progress has been made when it comes to implementation of ecological objectives in water management policy. The foundation of these objectives has become more clear and has been better attuned to other fields of policy. More clarity has also been realized on the question of how to handle these objectives in practice. If the flows of money which are involved in water management are considered in general, then the man-oriented objectives appear to prevail over the ecological objectives. Only a first step has been made on the road to an ecology-oriented protection and rehabilitation policy, at least in the province of Noord-Brabant. A fundamental rearrangement of the provincial organizational, managerial and administrative culture also seems to play an important part for successful integral policy planning at a provincial level. The national government is requested to evaluate the effectiveness of the legislation which is relevant for an integral policy and also to act in a more reserved and less sectorial manner in the "implementation" of national policy, as that may have a negative influence on the provincial execution of tasks. Let the provinces be the coordination centre, also when it comes to steering the general means which are available for the implementation and execution of the policy.

A successful ecological water management is completely dependent on the way the water

managers interpret and execute their task. There is an enormous scope for development here for the waterboards, also because of their functional nature. However, a precondition is that the authorities of the waterboards fully integrate the ecological policy objectives in their daily administration and management practice. National and provincial government must expressly give their attention to the creation of rules and regulations to provide the waterboards with better opportunities to give form and content to this new water management. But please let the waterboards not sit back and wait for that: anticipating administration is a requisite for the waterboard too!

## 1 RETROSPECT

In the seventies, after the effectuation of the Act against the Pollution of Surface Waters [Wet Verontreiniging Oppervlaktewateren (WVO)], a start was made with restoring the oxygen balance of surface water by building sewage water-treatment plants and by regulation of industrial discharges. The approach was source-oriented and - partly as a result of that - successful. As a yardstick for the success first the limit values and later a "basic quality" were defined to indicate how far away the goal still was.

As the decontamination programs progressed, increasing attention was given to the question what water quality should be aimed at. This was partly caused by the fact that in the early eighties in European Community framework water quality objectives for waters with a certain function were defined, like swimming water, water for salmonoids and cyprinoids, water for drinking-water production and shellfish. This emphasized that the degree of curbing discharges or the water quality to be strived after should be attuned to the function of the water. That was the emergence of the "quality approach" next to the "emission approach", which was also inspired by the wish not to spend more money than strictly necessary. The increasing WVO rates played an important background part.

In the indicative long-term program water [Indicatief Meerjarenprogramma-water 1980-1984 (IMP)] at a strategic level for the first time mention was made of the phenomenon "ecological" water quality objectives which could be defined in addition to "man-oriented" ones. This was the first political acknowledgement of the significance of surface waters as an ecological system. That meant a drastic revolution as for centuries the minds of the water managers had focused on making water serviceable to mankind. The surface water and the ecosystems in it were promoted to management object, while until then water had been a limiting condition for optimum (soil) use by man (building, agriculture etc.). That required a new approach and mobilization of new - mainly biological - disciplines in water management.

A "basic quality" as sole objective, or to put it more clearly: as standard, appeared not to be realistic any longer. But how does one define ecological standard objectives for surface waters? It took until 1988 before the Coordination Committee Implementation Act Pollution Surface Waters [Coördinatiecommissie Uitvoering Wet Verontreiniging Oppervlaktewateren (CUWVO)] published them in print (CUWVO, 1988).

The fact that it took almost a decade to get sanitary engineers, civil engineers, agricultural engineers and biologists on speaking terms on this point, shows how hard it is to really get ecological water management somewhere. Not to mention the every day management practice: how to handle the "do and don't" principles, which still are the basis for the levels indicated by the CUWVO for standard objectives for various types of waters. This contribution describes three aspects of ecological water management, particularly in relation to policy planning. The first part discovers what the significance is at the moment of the concept in water management planning. Subsequently, attention is given to the problems this entails for policy preparation, particularly at a provincial level. Finally we will look at the effects of the strategic policy in management plans and management practice. For that is what it is all about, handling water differently! This contribution has mainly been written on the basis of experiences in the province of Noord-Brabant. But undoubtedly the described developments and bottlenecks will be very recognizable for water people outside this province.

## 2 ECOLOGY INCORPORATED IN THE POLICY

The introduction of the concept water quality objectives in the second IMP water, as indicated above, was cause for heated discussions about its implementation. For those who defined the standards it was already a problem to work out the concept, and that was even more true for the planners and administrators who had to deal with financing and social forces. Fortunately the IMP mentioned "ecological" next to "man-oriented" water quality objectives. So it was first of all a matter of making a choice. That was reason that particularly those waters were assigned an ecological objective which were located in nature reserves or which still had a reasonably natural character. Assignment took place on the basis of a limited knowledge of current and potential ecological value and a limited insight into the coherence of the aquatic ecosystems with their relevant surroundings. This resulted in a fragmented management, very much like nature management till the eighties, while we should have tried to create self-supporting systems. There was quite some opposition against the assignment of ecological objectives amongst groups which had an interest in the man-oriented functions of the surface water.

After all, it was not clear what the long-term consequences were going to be for agriculture, recreation or drinking water supply. A compromise was often reached by "provisional" assignment and/or "feasibility research". This way the evaluation of nature and man-oriented interests was suspended, but the policy makers were also forced to start designing cost-effectiveness analyses.

Finally, there was the problem of the implementation of the ecological water quality objective. If substantial financial efforts are required to achieve swimming water quality it can be explained to administrators and it will find public support. Moreover, swimming water quality can be measured and defined in terms of physical parameters which makes it practicable as a policy objective. But what effort is socially "feasible" if it is a matter of bringing the crayfish back into our lowland brooks. And how do we calculate the required measures and how do we monitor the progress of the process?

Consequently, the first generation provincial water quality plans was rather reserved in defining the ecological water quality objectives and certainly in implementing them. As a matter of policy these objectives were still mainly discussed as a kind of luxury, a problem for the distant future. Certainly when it came to accepting the dire consequences from that function assignment.

But still a lot has been achieved in that field by now. The third Note on Water Management [Derde Nota Waterhuishouding] (Ministerie van Verkeer en Waterstaat, 1989) states that water management must both aim at having and preserving a safe and reliable land and at developing and maintaining sound water management systems which can guarantee a durable use.

So it is no longer a question of a choice between man-oriented and ecological objectives, but rather of how nature and man-oriented functions can be brought into balance again. Every surface water should at least house a healthy and viable ecosystem. That is the primary policy objective, which also applies to fully man-made water systems. It has nothing to do with the strive for natural, original ecosystems. That policy objective is being defined for those water systems or parts of those which qualify for it because of their current or potential ecological value. The question is at what level of natural function the policy should aim and - the other side of the coin - what level of human influence is considered acceptable. The "do and don't" standardization of the CUWVO is properly chosen in that sense.

The final aim is in most cases spelled out with the aid of target images and illustrated for instance with the amoebae from the third Note on Water Management.

For this objective, policy makers must first of all consider the question what measures can be considered realistic and feasible for a certain plan period and for a certain surface water or water system. The technical state of the art, social valuation and recognition of natural values at that moment in time, matters of finance and planning, have consequently become partly decisive for the question to what degree during the plan period it will be possible to implement the defined, ecological policy objective.

Precise predictions, in the sense of those plant and animal communities will stay or will return, are hard to give. But that is not the point; we are on the road to creating the preconditions for more natural circumstances. It is a remarkable fact that this approach finds both an administrative and a social basis.

The Brundtland report, Zorgen voor Morgen (caring for tomorrow) and the factual deterioration in our living environment are obvious signals that we must curb "excessive use" in a wide sense, which may also offer a basis for a different approach in water management. We cannot wait until we have a complete insight into the relations between measures and objectives and for cost-effectiveness analyses before making a choice between nature and man-oriented functions. Something has to be done now! That is nothing less than the political reality. These favourable circumstances in social attitude of course do not relieve the policy makers from the duty to define priorities and to introduce stages. In connection with the national and provincial environmental planning and nature policy quite some waters have been assigned a nature function in de draft Water Management Plan Noord-Brabant. The policy defined for these functions at least means an active protection, aimed at halting further deterioration. That applies both to water quality as to measures which might affect the hydrology or the morphology of the water system. In addition, a selective rehabilitation policy has been defined, particularly for water systems which are part of the ecological main structure. The policy aims at an integrated use of instruments (water management, town and country planning, environment etc.) to realize success sooner and on a wider scale. The limited means for nature policy must be put to use as optimally as possible.

On top of that it will be required that it is demonstrated that restoration of natural values really is possible. If we fail to achieve that, the consequence could be very soon that funds spent on nature policy are going to be regarded as money down the drain. Defining priorities for decontamination projects has taken place on the basis of "degree of opportunity", in which current or potential ecological value, influences and manageability determine the degree of opportunity. A fully dug-out brook with many sources of pollution, which must be decontaminated, gets a low score: a pool which can be dredged out cheaply and does not lie under further threat gets a high score. At a seminar organized in 1988 this method has been explained and this practical approach appeared to find a broad basis. Apart from the aforementioned policy for waters with a nature function, a general ecological function, applying to all water systems, has also been defined in Noord-Brabant. Perhaps we will know in a decade that this has been the most important objective.

With this basic function as guideline, water managers must consider the influence on the ecology of the water in question for all their actions, level control, maintenance, bank maintenance, issuing licences, incorporating in the existing infrastructure etc. As we increasingly succeed in realizing this integration in water management, we can make giant leaps forward. That can be illustrated with some figures. During the next plan period Noord-Brabant is expected to spend 90 million guilders on water management development measures of which - if al goes well - 30 million for specific measures for water with a nature function. The remaining 60 million guilders are still required for measures (land consolidation, A-2 projects etc.) which generally have negative effects on nature. If those 60 million guilders are not spent, or on a considerably more balanced approach - which we find more and more I am glad to say - the benefits for nature might be considerably higher than the result of 30 million guilders rehabilitation policy. And at much lower costs. In conclusion we may say that over the past ten years the implementation of the ecological standard objectives at administrative level has been given a much more solid basis and has been made more manageable. If the flows of money are considered we still cannot speak of a balanced implementation of the ecological functions compared to the man-oriented functions.

## 3 POLICY PLANNING AT A PROVINCIAL LEVEL

Above it was mentioned in passing that by now we are rather successful in properly harmonizing the horizontal and vertical policy. That refers to the harmonization of provincial to national policy and the harmonization between the various policy sectors on provincial level.

In Noord-Brabant the implementation of the national policy is the basic starting point for the provincial policy and at the moment three participation procedures are under way for a Regional Plan, an Environmental Policy plan and a Water Management Plan which are finely attuned to one another.

That is easy to say and it sounds logical. After all, the province is regarded as the governmental level which "is pre-eminently suitable to realize an integration of policies". That is where the water management policy is "embedded" in the general policy. Opinions which can regularly be heard in parliament and with which everyone agrees. Obviously it will not be possible to tackle problems such as acid rain or manure surplus, or to pursue a successful nature development policy, if the policies for environment, town and country planning and water management are out of step. Those individual plans play an integrating part in strategic policy planning at a provincial level. Traffic and transport policy, agricultural structure policy, nature development, land planning etc, for which often no legal plan regulations exist, must be tuned to these strategic plans. That is vital as those policy sectors can and must play an important supporting role in achieving strategic objectives while on the other hand the strategic policy must be favourable towards a successful policy in the mentioned sectors. In the course of this account already seven types of plans were mentioned in which civil servants and administrators are engaged in every province. Not to mention plans for socio-economic developments, recreation, shipping routes etc.

Gearing all those plans for one another, reaching agreement on the status and the hierarchy, the inter-departmental approach which is needed, all this requires a thorough revision of the provincial organization, management and administration culture. And the provinces are working hard on that too. Sectarian division must give a way to openness and vertical procedures must be replaced by horizontal ones. A project approach is being introduced, so that next to a line organization also a project organization develops. Administrators must make arrangements about the segregation of policy responsibilities which requires trust and amicable management.

In Noord-Brabant - to give just an example - five members of the Provincial Executive were more or less directly involved in the Water Management Plan (drinking water supply, administrative relations, town and country planning, environment and nature, and transport and communications). Consequently, they had to appoint a coordinator from among them, a function which requires courage, the administration must also be composed in a product-oriented manner! In other words, provinces must explicitly pay attention to their organization, management and administration culture to prove their integrating function in policy planning. If that does not get explicit attention, the integration philosophy will be a dead end and the effectiveness of the policy in a considerable number of sectors will decrease. It may be true that the province has been assigned a pivotal function in policy integration, but that does not relieve the national government from the obligation to pay attention to this aspect as well.

Progress can be perceived on that point, when a Nature Policy Plan, a third Note on Water Management and an Environmental Planning Policy Plan are developed at the same time and are reasonably successfully "amalgamated". This was not yet true in the case of the 4th Note on Town and Country Planning [4e Nota Ruimtelijke Ordening] (Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieuhygiëne (VROM), 1988). Every self-respecting department is now also engaged in the development of "their" notes or plans, although in view of the chosen allocation of tasks this should be done by the lower authorities. We could mention appointed areas by the forementioned ministery, dehydration projects of the Ministery of Traffic and Public Works, acidification projects, the implementation of the Nature Policy Plan etc. This course of affairs is sometimes cause for tricky competencies at a provincial level. The more so when this implementation policy involves (national) flows of funds. The province may have neatly developed an integrated policy and defined priorities, the departments decide where "their" money is spent on, whether that suits the provincial policy or not. That brings me to the conclusion that the national government should be less involved in the implementation of strategic national plans and that the national funds which come available should be allocated by the provinces. Provinces which manage to demonstrate a properly integrated policy should be awarded with national funds to enable them to pursue that policy.

The second issue which requires the attention of the national government, is a systematic evaluation of the legislation regarding aspects of policy integration and integrated execution of the policy. In the end the municipalities and the district waterboards are the ones who mainly bear the responsibility for the execution of the integrated policy regarding water management, town and country planning and environment.

If finally the provinces have worded this policy properly, will the execution automatically run smoothly then? It can be concluded that this is often not (yet) true and certainly not automatically. Adequate rules and regulations could promote this. I give an example to show you what I mean. Land planning is linked only with town and country planning. There are no zoning schemes for the rural areas, sewage management plans and environmental policy plans are not mandatory, there are no horizontal coordination obligations, etc. Evaluation in Noord-Brabant showed that the policy, which was realized after great efforts regarding sanctuaries and meadow bird reserves, was not sufficiently incorporated in the zoning schemes and, consequently, was only effective for 20% after a few years. Another point of attention for regulations is the possibility of sanctions and possibilities to issue directives. Pursuing an integrated policy successfully, requires that a large number of minds of various authorities, governmental institutions and other involved parties be steered into the same direction. That is the basic philosophy behind integrated (water) policy, which in itself is something to approve of. But now the reality, when the execution of a project with seven participants is hindered over and over again due to lack of cooperation from one party, then there is a need for a possibility to steer, even though that is only a last resort. So far a number of experiences and points of attention regarding policy planning at a provincial level. They seem to be beside the point when ecological water management is the subject. But to really give this management form and content, intense attention for these issues is vital, both on a national and on a provincial level.

## 4 FROM INTEGRATED PLANNING TO INTEGRATED MANAGEMENT

One could lecture dogmatic philosophies on the role of the district waterboards in public administration. They are brought in more often to argue that a district waterboard should refrain from doing something, than to show that they should take the lead in a certain development. On balance, the function of the district waterboard as purposive corporate body in public administration does not benefit by that in my opinion. It is true that we should always keep in mind the purposive corporate character, but at the same time we should keep up with the times. Particularly for the district waterboards just there are possibilities to develop themselves on a grand scale and to make themselves - demonstrably - indispensable.

Where the general democracy is experiencing an arduous balancing process of guilders for environment, housing and so on, the district waterboard should prove the usefulness and the necessity of its limited scope in its daily actions. In Noord-Brabant that is a point where - in a challenging way - the attention of the district waterboards is drawn to. There is no confidence in an administrative structure in which the province is involved in details and execution. That is and will remain a matter of "it's not my cup of tea" and it will not have any results whatsoever as it is not recognized in the regions and it has no social basis.

For that reason district waterboards are invited to take up their environmental task with fervour, to establish cooperation frameworks with water supply companies, to think about the effectiveness of their own organization, and to actively embark upon the implementation of the provincial plans which have been developed in cooperation. That means ample opportunity to score. Now the question is, whether the district waterboards are going to take up the gauntlet. There are both positive and negative experiences on that point. All kinds of notions which have found general acceptance nationwide in waterboard circles, e.g. regarding to the performance of tasks in urban areas or in nature areas, only live up to their promise very gradually. Sometimes it happens that municipalities build weirs at their own expense for nature areas which pay waterboard levies.

In administrative bodies people are arguing about the question whether or not environment-friendly banks and fish passages should be part of the task of water administrators etc. Lovely plans for decontamination of a brook with a view to restoring the ecosystem do not reach the administrators or they are rejected because it is questioned whether it should be part of their task. The district waterboard does not do itself a good turn this way. After all the crux of the matter still is how do we execute water management while giving the ecosystem serious consideration as a policy objective. In view of the national and provincial plans for water management there should no longer be any misunderstanding on this point by now. In the same way as the provinces have to take up their newly assigned task and have to take the sometimes far-reaching organizational and administrative consequences, the district waterboards should also work on that intensively. Fortunately there are positive signs too. Administrative bodies which until a few years back only took into account considerations of land development when deciding how to modify water courses, now accept the nature function and designations which have been defined in the framework of provincial planning. Some of them even begin to regard it as a privilege and a challenge: to give form and content to water management in those nature areas which have become rare.

At the earlier mentioned seminar on ecological standard objectives in Noord-Brabant, the representatives of the district waterboards advocated an active role of the waterboard in the difficult process of realizing a practice-geared rehabilitation policy for water systems, in which various political bodies are involved. Those are promising signs, but what really matters is, what their actions will be. With this we should naturally not forget that the water managers also need a reasonable set of instruments to be able to live up to their promises. That is where the responsibilities for national and provincial authorities lie. The national government must make it possible for the district waterboards to perform the tasks assigned to them, also financially speaking. That means introduction of the Act on District Waterboards, amendment of the Act against the Pollution of Surface Waters etc.

The financing framework should be geared for the changing task package. Provinces must arrange for adequate rules and regulations, both regarding the task description and the instruments which are available to the district waterboards, in view of the new tasks and particularly the way those tasks are performed. But do not allow the waterboards to use the slow progress in these fields as an argument to stand still. They are expected to realize an anticipating administration which adapts to the new demands and ideas, as this also applies for public administration in general. Provinces also work out national government notes of which the ink has not yet dried and which still have to be adopted by parliament. The history of the waterboards proves that they have always been able to do so. The vital question is whether the waterboards are aware of those new objectives for water management, which are also or even mainly adapted to ecological functions. If so, there isn't a worry in the world about the effectuation of that policy.

## REFERENCES

CUWVO; 1988. Ecologische kwaliteitsdoelstellingen voor Nederlandse Oppervlaktewateren. Coördinatiecommissie Uitvoering Wet Verontreiniging Oppervlaktewateren. 154 p.

MINISTERIE VAN VERKEER EN WATERSTAAT; 1981. Indicatief Meerjarenprogramma-Water 1980-1984 (IMP).

MINISTERIE VAN VOLKSHUISVESTING, RUIMTELIJKE ORDENING EN MILIEUHYGIËNE; 1988. 4e Nota Ruimtelijke Ordening.

MINISTERIE VAN VERKEER EN WATERSTAAT; 1989. Derde Nota Waterhuishouding. Staatsuitgeverij 's-Gravenhage, 297 p.

**Ecological Water Management in Practice** (Proceedings of the technical meeting held in Ede, The Netherlands, 3 October 1990). Proceedings and Information CHO-TNO, no. 45, 1991.

# REVIEW

J.A.W. de Wit

## 1 INTRODUCTION

The contributions to this technical meeting have shed light on many aspects. It would be impossible to summarize them. Moreover, many elements can be found, though perhaps differently phrased, in the publication of the Advisory Council for Research on Nature and Environment [Raad voor het Natuur- en Milieuonderzoek (RMNO)] "Ecological Aspects of Integrated Water Management" [Ecologische aspecten van Integraal Waterbeheer] (De Vries et al., 1989). I will try to distil the main issues from the contributions by answering the following four questions, naturally without refraining from giving some personal comment:

1) What is ecological water management?
2) What is the state of knowledge for application in practice?
3) Is this knowledge available?
4) Who should do it, and what is the task of the water authority?

## 2 WHAT IS ECOLOGICAL WATER MANAGEMENT

As the many examples discussed in this special issue show, ecological water management appears in many forms. Of course, this is to be expected in integrated water management which focusses on water systems. Scale and characteristics of water systems can vary considerably, while functions and aims connected to a water system differ widely as well.

Also the results of ecological water management do not always have to be as clear and visible as in the examples Higler quotes.

My attempt to formulate a definition of ecological water management would be: Ecological water management focusses on enhancement or conservation of natural values/potentials according to scientific-sound ecological principles.

It is useful to distinguish two different types of ecological water management:

1) Active ecological management.
   In this type one of the primary aims of management measures is directed at enhancement of natural values. Gardeniers especially applies his analysis to this form of ecological water management and gives examples as well.

2) Ecologically suitable management.
   This means that the primary aim of the measure serves another function connected to the water system, e.g. the discharge of water, while trying to consider the functioning of ecosystems as much as possible. An example is a method of cleaning ditches and storage waters not all in one go, but allowing certain types of vegetation to recover first.

The contributions of the speakers all stressed the first form of ecological water management, and undoubtedly not without reasons. One of the reasons is that large-scale projects are often involved which are clearly identifiable and yield more profit in terms of nature.

Nevertheless I would like to stress, as did Provoost in his presentation, that both forms of ecological water management are important. Especially in a situation as in the Netherlands, where water management and use of the water are very intensive, much profit (though less spectacular) can be gained by increasing the ecological suitability of management measures. The great diversity of ecological water management entails at the same time that there is no ready-made recipe for every situation. A large number of initiatives has come up, but experience is still limited. Even if this want of experience is remedied, it is still doubtful whether there will be ready-made answers to all questions. The lack of recipes, however, does not mean that we are left empty-handed. We know a number of important ingredients.

In international as well as national circles, the concept of sustainable development as a norm for human actions is already widely accepted (WCED, 1987; Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, 1989). In water management it is an accepted standard as well (Ministerie van Verkeer en Waterstaat, 1989). For a wide range of functions that a water system should serve, the concept sustainable development applies as a standard in connection with the ecological functioning of the water system. A sustained ecological functioning of water systems is then especially judged by the following criteria:

- diversity and variety;
- natural quality and self-regulation.

(Ministerie van Landbouw, Natuurbeheer en Visserij, 1989; Ten Brink and Hosper, 1990).

When ready-made management guidelines are lacking, these two starting-points offer a useful basis for ecological water management. A further elaboration and concretization, however, is desirable. This is illustrated by some examples Higler gives in the second part of his contribution.

## 3 WHAT IS THE STATE OF KNOWLEDGE FOR APPLICATION IN PRACTICE

I have already remarked that there will not be ready-made recipes for all situations. Yet there are situations which occur often, and knowledge of which must be available in a usable form. In general the following components can be distinguished:

- formulation of problem and aim;
- development of measures.

The contribution of Verdonschot focussed on the first step, which has received much attention in the last few years on government level (Ministerie van Verkeer en Waterstaat, 1989) but also on provincial and waterboard level. The resulting studies vary widely in their details, but in the process passed through I still see a number of recurring elements (Figure 1).

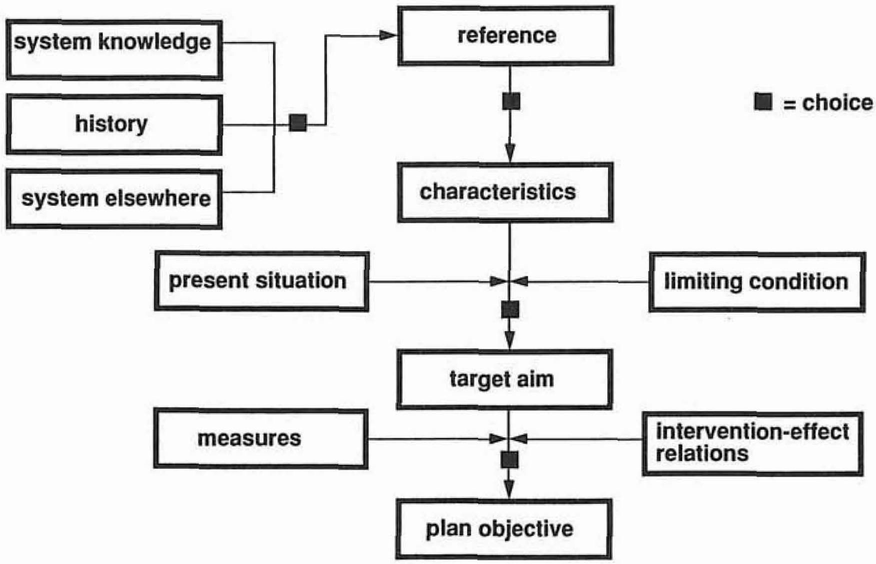



Figure 1 The development of an ecological objective for a water system

It is a question of trying to find a reference image for the ecological functioning of a water system. Verdonschot refers to this as development directions. This may be a situation from the past or another water system which has less been subjected to influences of any kind. It is also conceivable that, of both, information is not available or not at all usable. The latter is very well possible in the case of waters that are man-made or changed beyond restoration. Then a reference will have to be drawn up based on theoretical concepts or expert opinions.

Consequently it will be clear, and Verdonschot stresses this as well, that there is not one single reference, but that a social choice will have to be made. A selection of characteristics should be made. Because of the ecological objective, this will in any case concern a number of biological characteristics. Besides these abiotic characteristics linked to them can be chosen as well. The selection of characteristics is necessary to enable a comparison between the actual situation and the reference situation and can be used in formulating concrete aims as well. Many of the discussions concern this selection of characteristics, and at first the differences between the opinions seem large. Compare for example the "amoebe" approach of Rijkswaterstaat with the hydrobiological typology such as Verdonschot applied to the province of Overijssel. We should however also take into account that the selection of characteristics is not only a scientific affair, but is definitely connected to the framework of the process gone through (Klijn et al., 1990). A policy study, for example, will have to consider the acceptance of characteristics by the government and the public. Moreover, all kinds of pragmatic considerations play a part. What knowledge do we have, what can we measure? Looking at the matter against this background, I do not attach much importance to the differences in approach, especially where the practical implications for water management are concerned.

Finally an objective should be formulated in quantitative terms. This often means that first a direction and a level are indicated, without a judgement of the feasibility of the proposed measures or time limit. This is what I call the target aim. It may be the reference situation, but can also differ from it, e.g. where a desired link with other functions is concerned. On the path between the actual situation and the target aim a concrete plan objective should be chosen by means of an iterative process of aims and measures.

The development of measures necessitates knowledge of "intervention-effect-relations". The contributions to the workshop and the forementioned RMNO-report "Ecologische aspecten van integraal waterbeheer" show that we have a fairly adequate knowledge of the relationships in the qualitative field. This means that the type of measures to be taken is also known. Where quantities are concerned, however, knowledge is insufficient. That is why one of the three priority recommendations from the RMNO-report indicates in that direction: "Gaining insight into intervention-effect relations in notably small waters and the specific problems occurring in them...". A recommendation which has my full support. This does not mean that it is a simple matter. Higler's and Verdonschot's diagrams show that the system we are dealing with is complex and that there is a large number of relations. An extra complicating factor is that changes which have occurred are only rarely isolated cases. It is often a matter of a large number of changes which take place parallel and show mutual relations (e.g. in the case of brook regulations). So, when we try to find intervention-effect relations, they will not always be one-dimensional relations.

This brings me to the following conclusions. A selection and definition of intervention-effect relations which we consider important is urgently needed. The RMNO-report gives an initial impetus, but certainly deserves to be supplemented and elaborated. The great lack of knowledge in this field does not mean that we should refrain from taking measures for the time being. As I mentioned before, we do often know the type of the measures, so a start can certainly be made. Such a project should, however, be accompanied by thorough research, which fortunately already happens. Many examples have been mentioned. I myself would like to add the many initiatives in the field of bank construction and biomanipulation.

## 4 AVAILABILITY OF KNOWLEDGE

Finally it would be good to pay some attention to the accessibility of the knowledge that is available. The RMNO-report discusses this question in a separate chapter. The conclusion is that the information exchange between researchers and water authorities is inadequate. Some, in my opinion very good, recommendations are given concerning publications on experiences, practice handbooks, meetings between authorities and researchers and courses. I will look closer at practice handbooks and courses. Certainly when compared to the countries surrounding us (England, Germany), there are very few activities in this field in the Netherlands. There have been some good initiatives, such as the Handbook Environmentally Sound Banks by the Civil Engineering Centre for Research and Regulation and Rijkswaterstaat (CUR, 1990), a publication from the Ministry of Agriculture, Nature Management and Fisheries on designing fishing waters (Ministerie van Landbouw, Natuurbeheer en Visserij, 1990), the handbook on biological water assessment, and a manual on the application of biomanipulation that is in preparation at the moment. However, this is only a limited number of subjects. Many other subjects are suitable for such an approach, e.g. biological monitoring, the maintenance of small water courses, improvement of fish passes, restoration of lakes.

It is remarkable that several agencies have taken an initiative, but that water authorities have never or only indirectly taken the lead. In my opinion this is certainly a task of the joint water authorities. I could make similar remarks about courses. There have been many ad hoc initiatives, but a more systematic activity, initiated by the water authorities themselves, would be desirable.

The RMNO-report does not indicate who should take this matter in hand. I would like to make the concrete suggestion that the Dutch Union for Waste Water Treatment [Nederlandse Vereniging voor Afvalwaterbehandeling en Waterkwaliteitsbeheer (NVA)] should take the lead. The NVA has already gained valuable and broad experience with similar activities in the field of water quality management. An extension involving ecological water management is a logical and in my opinion very desirable step.

## 5 WHO SHOULD DO IT, AND WHAT IS THE TASK OF THE WATER AUTHORITY

In ecological water management the task and possibilities of water authorities are constantly involved. The Third Note on Water Management [Derde Nota Waterhuishouding] (Ministerie van Verkeer en Waterstaat, 1989) discusses them in detail. This aspect was also a prominent feature in the contributions to the technical meeting, especially those by Deurloo and Provoost.

Deurloo points out that ecological water management poses new requirements, both to the "external" role of the water authority itself, and to the "internal" method of work. Ecological water management is not an affair of the water authority alone; many measures must be taken by other responsible agencies. So, the water authority is not by itself, but together with others responsible for the water system. The policy and management plans, which should be drawn up together with other authorities and policy makers, should offer a framework for the management which is carried out within the own responsibility. This requires much from the water authority's powers to coordinate and integrate.

Internally speaking, the fact that the water authority embarks on new fields of work when tackling ecological water management, means that he must be well informed of the possibilities and developments in other policy sectors. New insights should be gained concerning basic principles and design criteria for his own management. Both changes entail extending of refreshing of professional knowledge in other fields.

So, although water managers are only one party among many, I find it important to stress just the initiator's role of the water authorities where ecological water management is concerned. Strictly speaking, their own responsibility is limited. However, the boundaries of today are on the move. One of the lessons of history is that this happens when water authorities start on new tasks, which e.g. happened recently with water quality management. In the case of ecological water management, it is a matter of modernizing the interpretation of their task. It is important to keep moving and to consider new questions with a certain pragmatism. Especially when we look at the extent of the damage done to the nature of our waters, we are still at the beginning of the process.

So we should not expect to get an immediate answer to fundamental questions, questions which are, however, important. But it takes more time to get the answers, and we have more time. Ecological rehabilitation will take decades yet.

What should water authorities do and what not? In any case it is essential that the water authority plays his role of initiator adequately. After all the water authority is pre-eminently the one who promotes all the interests involved in water. Human-oriented interests are often well represented there. There is no obvious interested party for ecological functioning, or it should be the water authority itself. The water authority can take the initiative to ask, or even force, others to think along and make a contribution. Fortunately there are already many good examples. Let them be a challenge to others. We will have to do our utmost for the conservation and restoration of nature in our waters!

## 6 CONCLUSIONS

Ecological water management appears in many forms. Besides nature-oriented projects, the ecological suitability of the usual management deserves attention as well. Ready-made guidelines are often lacking, but starting-points which offer a useful basis can be indicated.

Much attention is paid to the formulation of problem and aim concerning the ecology of waters. A pattern can be distinguished there, but the ways in which it is elaborated by the various water authorities differ widely. Where water management is concerned, this is no problem. Research should be more directed at intervention-effect relations. The nature of the measures to be taken is sufficiently known to make a start.

The availability of knowledge should be improved. The water authorities themselves should play an active role in stimulating the preparation of handbooks and courses on ecological water management.

For the water authority, ecological water management is a next step in his historical evolution. This has consequences for the external and internal performance of his task. Together with others the water authority is responsible for ecological water management. The water authority may, however, be expected to play an initiator's role, based on the responsibility for and involvement in all the interests concerned with water.

## REFERENCES


TEN BRINK, B.J.E. and HOSPER; 1990. Naar toetsbare ecologische doelstellingen voor het waterbeheer: de AMOEBE-benadering.

KLIJN, F., LATOUR, J.B., NIP, M.I., GROEN, C.L.G., UDO DE HAES, H.A., VAN DEN BERG, E. and HOFSTRA, J.J.; 1990. De milieukwaliteit van ecodistricten. Deel 2: Methode en aanzet tot uitwerking. RIVM-rapport 751901003, CML mededelingen 63.

MINISTERIE VAN LANDBOUW, NATUURBEHEER EN VISSERIJ; 1989. Natuurbeleidsplan, beleidsvoornemen.

MINISTERIE VAN LANDBOUW, NATUURBEHEER EN VISSERIJ, Directie openluchtrecreatie; 1990. Vormgeving en inrichting van viswater.

MINISTERIE VAN VOLKSHUISVESTING, RUIMTELIJKE ORDENING EN MILIEUBEHEER; 1989. Nationaal Milieu Beleidsplan. Staatsuitgeverij.

MINISTERIE VAN VERKEER EN WATERSTAAT; 1989. Derde Nota Waterhuishouding: Water voor nu en later. V&W, 's-Gravenhage.

DE VRIES, I., BAAN, P.J.A., HIGLER, L.W.G. and VERDONSCHOT, P.F.M.; 1989. Ecologische aspecten van integraal waterbeheer. Programmeringsstudie. Publikatie RMNO nr. 41.

WCED; 1987. Our common future. Rapport van de Brundtland Commissie.

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