GROUNDWATER IN THE WATER FRAMEWORK DIRECTIVE

ADVISORY REPORT OF THE GROUNDWATER WORKING GROUP TO THE TCB

GROUNDWATER IN THE WATER FRAMEWORK DIRECTIVE; ADVISORY REPORT OF THE GROUNDWATER WORKING GROUP TO THE TCB

This advisory report was approved at the meeting of 26 July 2001.

On behalf of the working group,

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1 INTRODUCTION: GROUNDWATER IN THE WATER FRAMEWORK DIRECTIVE

The Dutch government is preparing for the implementation of the EU Water Framework Directive (1). Implementation requires technical-scientific support. The Soil Protection Technical Committee (hereinafter also referred to as the TCB) has been requested to advise on the consequences of aspects relating to groundwater[1]. The committee has asked the TCB Groundwater working group to assist it in this task because the questions concerning the directive's implementation are directly related to surveys the working group had previously started[2]. This report contains the working group's reply to the questions the Minister put to the TCB. The report contains the viewpoint of the Groundwater working group and can be read as a separate document. For the TCB's final viewpoint, see advisory report TCB S44(2001). This ties in with the working group's recommendations.

The EU Water Framework Directive (WFD) came into force in December 2000. The directive is intended to coordinate environmental objectives and measures within the scope of water policy in various member states. The directive obliges member states to develop policies intended to restore and protect water systems. It is intended to serve as a policy framework within which, adopting a river basin approach[3], EU member states can take measures to 'restore aquatic systems and/ or prevent their further deterioration' (art. 1). The main instrument for this is the river basin management plan, which has to be drawn up for each river basin. Within river basins, a distinction is made between surface water bodies and groundwater bodies, for which the achievement of a 'good status' has been defined as an environmental objective. For surface water, a distinction is made between a good

1 The request for an advisory report is included in Annex I.

2 The TCB established the working group to indicate how the relationship between groundwater management, spatial planning and environmental management can be reinforced and how the link between management and the properties of groundwater systems can be improved. Information on the working group's composition is provided in annex II.

3 The WFD defines a river basin as (art. 2): an area from which all the water running over the surface flows into the sea through a single river mouth, estuary or delta, via a series of streams, rivers and possibly lakes.

chemical status and good ecological status. For groundwater, a distinction is made between a good chemical status and a good quantitative status[4].

The TCB was asked to specifically examine the following groundwater aspects:

- criteria for the scale of groundwater bodies, taking into account the geohydrological make-up of the Netherlands and the relationship to surface water;
- criteria for assessing the good chemical status of the groundwater (including applying a framework of standards for an as yet to be specified set of parameters), taking into account the depth of the groundwater;
- criteria for determining a significantly and permanently increasing trend in concentrations of the relevant parameters and for determining the starting point for realising a reversal in this trend;
- the required monitoring programme, the way in which data can be aggregated (in space and time) and presented, and any model instruments that may have to be used.

The working group replies to all the specific questions it was asked and also makes a number of general recommendations on the way in which groundwater systems ought to be managed.

ORGANISATION OF THIS REPORT

Chapter 2 defines the starting points on which the working group's standpoints and recommendations are based. The starting points are worked out roughly in chapter 2 and in greater detail in the discussion of the subjects that are covered in chapters 3, 4 and 5.

In chapter 3, the working group discusses the scale of groundwater bodies. An indication is provided of the principles that can be used as the basis for the scale and details are worked out on a nationwide basis by means of a division into areas. Finally, there is a discussion of the scale problem of management.

In chapter 4, the working group discusses the good status for groundwater and the starting point of reversal. For a proper understanding of this chapter, it is necessary to read chapter 3.

[4] Good chemical status and good quantitative status for groundwater are defined in chapter 4.

Chapter 5 is concerned with monitoring. Preconditions are given for monitoring within the scope of river basin management and there is a discussion of the extent to which the present monitoring networks meet the requirements for this.

Chapter 6 is a summary of the working group's recommendations.

2 STARTING POINTS IN THE ADVISORY REPORT

The working group analyses WFD from a natural science perspective. It specifically examines the integration of knowledge of the properties of the managed groundwater systems and the connection between the WFD and current practice[5].

The analysis of the WFD's implementation is based on the following starting points:
1) the WFD's implementation should contribute to better integration of qualitative and quantitative water management;
2) the WFD's implementation should be geared as far as possible to the specific geohydrological situation in the Netherlands;
3) the WFD's implementation should be geared as far as possible to current practices in soil and groundwater management.

These starting points are discussed in general terms in this chapter. They are worked out in greater detail in the following chapters.

TOTAL GROUNDWATER MANAGEMENT IN THE WFD

The WFD's implementation should contribute to better integration of objectives and measures within the scope of qualitative and quantitative water management. A condition for achieving that integration is that more attention needs to be paid to the effect of water management intervention on chemical and biological quality and vice versa.

The quality and quantity of groundwater are too often considered separately: in the case of groundwater quality, there is a tendency to think too much in terms of the impact on the soil/ groundwater system of pollutants; in the case of quantity, there is a tendency to think too much in terms of surface water levels, abstraction flow rates and groundwater levels. However, aspects that are traditionally seen as purely quantitative or purely qualitative are very interrelated. Deterioration in chemical

5 During previously conducted surveys (2, 3), the working group established that better integration of physical, chemical and biological insights into groundwater systems is a precondition for strengthening the relationship between groundwater management, water management and soil management, and for ensuring the management relates properly to the properties of groundwater systems.

quality is often also caused by water management intervention and not only by pollution through anthropogenic supply.

An example is deep drinking water abstraction from occurrences of groundwater, in which case the groundwater's composition is not affected by human activities. Groundwater abstraction reduces the seepage pressure of high-quality, deep groundwater, to the benefit of shallow, anthropogenically polluted low-quality groundwater. This means more of the polluted groundwater is fed to ecosystems that are dependent on groundwater and less of the high-quality groundwater seeps up than was previously the case. This reduces the quality of the groundwater on which the ecosystems depend. The result may be the deterioration or disappearance of vegetation that is characteristic of the ecosystem (4). The abstraction may therefore present a threat to the existence of these ecosystems. This can be observed in, for example stream valleys in North Brabant, where specific stream valley vegetation is under pressure. However, industrial abstraction by, for example, the paper industry in Apeldoorn also has the same effect (5).

Level reduction in deep-lying polders also leads to effects that extend beyond quantity. Level management results in peat settling. Increased levels of nutrients and arsenic are released from the peat into the groundwater (6). Moreover, a reduction in polder levels leads to more seepage of (saline) groundwater. In the winter and early spring, polder water is usually transferred to the storage basin. This results in extra eutrophication and/ or salinization of surface water. In the summer, there is often a shortage of water in deep polders, which in turn has to be offset by allowing in water that is not from the area.

Finally, projects changing land to wetland are an example of water management intervention that may result in unforeseen quality deterioration. Rewetting can lead to increased concentrations of sulphide and phosphate in groundwater and surface water, which can result in waterplant toxification or eutrophication (7). In many cases, the substances that present a problem because of water management intervention are largely of natural origin (7, 8).

The approach to many water and groundwater problems could be improved by working out the quality and quantity aspects in relation to each other for each river basin. The working group considers this as the essence of the integration that has to be achieved through the WFD's implementation. The integration should make it possible for management to be more in line with the properties of groundwater systems and for it to take place in a less fragmented way, in the form of topics that can be worked out independently of the systems being managed.

The working group believes the required integration can be achieved by using quality as the main starting point in river basin management and to largely consider quantity in terms of its effect on quality. The following two aspects need to be combined in river basin management of this kind:

1) Groundwater flows and management of flow paths, insofar as quality developments in groundwater bodies are related to the distribution of substances in the system[6].
2) Hydraulic heads[7] and maintenance or restoration of seepage pressure and groundwater replenishment[8] of deep aquifers, insofar as quality developments are concerned with the availability of groundwater of a particular quality for terrestrial and aquatic ecosystems.

THE WFD'S CORRESPONDENCE TO THE SITUATION IN THE NETHERLANDS

For the WFD's implementation it is necessary to take into account a number of aspects that apply more or less specifically to the Netherlands. The points for special attention concern the geohydrological situation closely connected with the human factors: soil use, groundwater use, and water management:

- The river basin approach in the WFD is mainly based on the assumption that, after underground transport, groundwater enters surface water and affects the quality of surface waters. The Netherlands is mainly a delta area, in which river water also infiltrates groundwater. It is necessary to take into account that it is surface water that affects groundwater quality and quantity in these situations. Groundwater quality management in the Netherlands may therefore involve task setting for surface waters and even for upstream areas outside the borders of the Netherlands.
- Water systems and groundwater systems in the Netherlands are highly regulated. The regulations are closely related to the intensive use of the soil and water (for agriculture and industry, for example) and to the fact that areas in the lower Netherlands have been made habitable by impoldering. Groundwater

[6] Flow paths are imaginary paths that indicate the direction of the groundwater flow at each point and form part of a flow pattern.
[7] The hydraulic head is the height of the water level in an observation tube with respect to the NAP level, which is approximately the mean sea level.
[8] Groundwater replenishment means the surplus precipitation that is carried to the groundwater from the unsaturated zone.

is therefore a factor that has to be taken into account practically everywhere in the Netherlands. This requires management on a smaller scale than that assumed in the WFD. In the Netherlands, a distinction is made between the river basins of the Rhine, Meuse, Eems and Schelde. It is therefore very important for the Netherlands to exploit the possibility of designating partial river basins, in which management can be carried out on a smaller scale[9].

- The WFD assumes that the good status in water systems will finally be achieved in the year 2015. This period is extremely short for most of the groundwater systems in the Netherlands. In the Netherlands, the underground (down to less than 500 metres below ground level) consists of sedimentary deposits that behave as a porous medium for groundwater transport. The groundwater flow in this medium is slow and gradual. When establishing environmental objectives for groundwater systems, it is necessary to take into account this slowness.
- The WFD's starting point for the management of groundwater bodies is the functions they fulfil. Groundwater often fulfils several functions at once, owing to the intensive soil use and groundwater's close connection to processes at ground level. In such cases, it is not possible to only attribute a single function to a groundwater body.

THE WFD IN RELATION TO GROUNDWATER MANAGEMENT AND SOIL MANAGEMENT

The demarcation of the scope of river basin management is important in linking the WFD to the current practice of groundwater management and soil management. The WFD has an extremely integrated character. Management is generally concerned with all types of impacts on water systems that may have a detrimental effect. It is therefore not only concerned with the pollution of water systems but also with abstraction, drainage and bacterial contamination. The working group therefore prefers the term impact for the detrimental effects of human action on water systems rather than the term pollution.

A number of aspects of groundwater management are beyond the scope of river basin management. Therefore, the directive's implementation does not cover all aspects of

9 If water systems in the Netherlands are managed on a smaller scale than four river basins, a distinction in reporting can be made between the report required in compliance with the WFD to the EU (concerned with information on the situation of water systems at the level of the large rivers) and information that is aggregated in the smaller, relevant partial river basins for carrying out the water and groundwater management.

groundwater management. There is, for example, heat/ cold storage, the construction of physical barriers in the aquifer that carries the groundwater, such as cellars, deep excavation sites and dam walls, or the management and remediation of groundwater pollution in urban areas. Problems of this kind are extremely specific. They are best solved in separate, sometimes existing frameworks. In general, the working group suggests considering urban soil and groundwater management as a separate activity. Management of this kind must obviously be geared to the WFD; soil and groundwater management in urban areas must not prevent management objectives within the scope of the WFD from being achieved.

As indicated in chapter 4, the body of groundwater that is relevant for groundwater management extends to a depth of 500 metres below ground level. This depth also indicates the range of groundwater management within the scope of the WFD. Management frameworks, such as the Mines Act, cover activities in the deeper underground. The TCB report on the deep underground and soil protection ('Diep ondergrond en bodembescherming') discussed the required management framework for the deep underground (9).

3 SCALE OF GROUNDWATER BODIES

The WFD requires management plans for river basins to be based on a characterisation of the water systems. Part of the characterisation is the determination of the location and boundaries of groundwater bodies (WFD, Annex II, chapter 2.4.1). In considering the scale of groundwater bodies, the working group took into account the geohydrological make-up of the Netherlands and the relationship to surface water.

This chapter first describes the starting points that form the basis for the working group's recommendations on the scale of groundwater bodies . This is followed by a discussion of the classification of groundwater bodies on the basis of the geohydrological relationship between groundwater systems in an area. An indication is provided of how geohydrological uniformity can bring about organisation without losing sight of the dynamics of groundwater flow. The working group indicates the scale level in space and time that can be used when looking for geohydrological relationships. A specific proposal is presented for area divisions. The working group examines the similarities and differences between this proposal and the indicative division of the Netherlands into river basins in accordance with the 21st Century Water Management Committee (10). Situations are then examined in which it is necessary to switch to management on a smaller or larger scale. The chapter ends with a summary of the working group's recommendations.

STARTING POINTS

The scale of groundwater bodies must meet the following conditions:

- The scale must aid the integration of groundwater quality and quantity. Against the background set out in chapter 2, this means the integration of flow path management and the management of hydraulic head and seepage pressure.
- The scale must make it possible to relate the effects of soil/ groundwater use to the quality of groundwater and surface water, within groundwater bodies (link between cause and effect).
- The scale must be a measure of the size of the management units.
- The scale should be geared as far as possible to the division of the Netherlands into the four river basins of the Eems, Rhine, Meuse and Schelde and to the river basin approach adopted in the WFD.

General demarcation

The section of groundwater that is relevant for management can be demarcated in the upper Netherlands on the basis of the fresh/ saline interface. Groundwater in these areas, with chloride concentrations equal to 17,000 – 18,000 mg/ l, can be designated as old seawater and is not covered by the management. The depth of this interface is no more than 500 metres below ground level. The groundwater management therefore extends down to several hundred metres below ground level. In the lower Netherlands, saline groundwater is closer to the soil surface, owing to the presence of old seawater in the first few dozen metres below ground level and as a result of drainage in deep-lying polders. In seepage situations like this, the saline groundwater does form part of the system being managed.

GEOHYDROLOGICAL RELATIONSHIPS

Before the dimensions of groundwater bodies can be indicated, there has to be clarity about which characteristics are used to determine that groundwater bodies form a unit. The working group has assumed geohydrological relationships are used for this. Groundwater bodies are considered as geohydrologically related management units[10]. To a certain degree, these units have a uniform hydrological and geological situation. They consist of a collection of groundwater systems of various sizes. The systems in a geohydrological management unit respond in a similar manner to impacts, owing to the uniformity in the hydrological and geological context. The geological context is the static aspect, the whole of the layers and formations that groundwater flows through, which must be known to enable forecasts to be made and understood about developments concerning groundwater.

The groundwater systems that form part of geohydrological management units are dynamic. There is a dynamic relationship in the systems between an infiltration area[11] with a hydrologically associated exfiltration area[12]. The relationship can be made visible and analysed by flow paths. Figure 1 provides an illustration. Characteristics of groundwater systems are:

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10 The term groundwater body is therefore synonymous with geohydrological management unit.

11 An infiltration area is an area in which water enters the waterbed or soil and feeds the groundwater.

12 Exfiltration area (also known as seepage area) means the area in which the groundwater flow reaches the soil surface, surface water or drains.

- They have a starting point and an end point. In natural situations, the starting point is the infiltration area and the end point is the exfiltration area; this is where changes in quality take place at ground level[13].
- Because of the dynamic character, the boundaries may change through water management intervention in the surface water (by changing the water level, for example), through intervention in the underground (such as water drainage or groundwater abstraction), through impoldering operations and inundations[14], or through changes in precipitation intensity. This is important when determining the size of the management units because a shift in the boundaries of a groundwater body that has already been demarcated can cause problems for its management.
- Distinctions in groundwater systems and clusters of systems can be made at various scale levels; this is explained in greater detail in the next section.

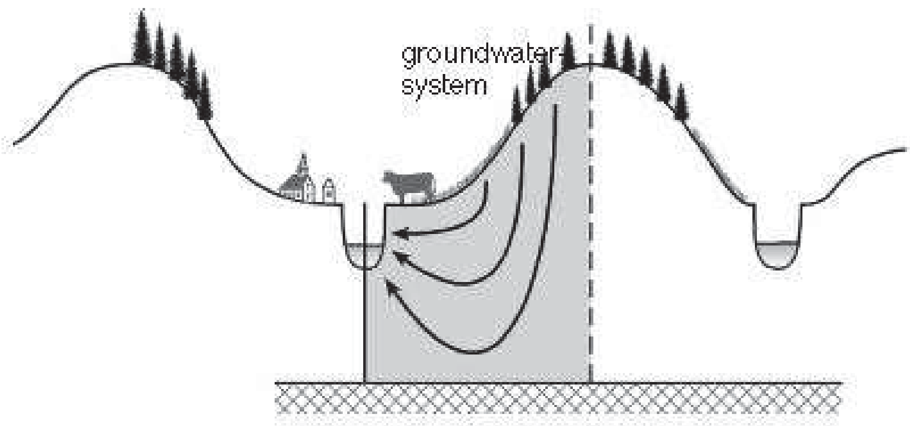

Figure 1. An example of a groundwater system with an infiltration area and exfiltration area.

The approach to groundwater bodies as geohydrologically related units provides a number of advantages that are important for management:

- Geohydrologically related units indicate a relationship in groundwater flow. Groundwater flow can be considered as the carrier of quality developments in a groundwater body. Analysing flow path patterns makes it possible to establish a link between an impact on groundwater bodies and the effects in groundwater bodies or ecosystems that are dependant on groundwater.

[13] Starting and end points of this kind can also be introduced through human intervention; an abstraction point is an end point of a geohydrological system with an associated infiltration area.
[14] This means putting the land underwater.

- Statements about cause and effect can be placed in a timeframe. It is possible to clearly indicate when the consequences of an impact on groundwater or of recovery measures will be apparent at ground level.
- The approach is in line with the river basin approach of the WFD. In the directive, a river basin is considered as an area in which the outflowing water meets in an outflowing system, such as a stream, river, lake or sea. The same applies to a groundwater system, although a third dimension is added.
- The distinction made between related groundwater systems also provides an insight into related hydraulic head patterns. As indicated in chapter 2, the working group considers the hydraulic head to be an important aspect of groundwater management.

A disadvantage of the division into geohydrological management units is that the boundaries of systems arranged in this way may change over time, owing to their dynamic character. A spatial demarcation that is stable over time is needed. This can be achieved by, as far as possible, focusing the demarcation on the boundaries of hydrogeological units that coincide with geographical landscape units. This applies to the water divide between, for example, two river basins that lie under a topographical height. These are more or less stable and have been properly charted. This makes demarcation on a map possible.

Scale levels of groundwater systems

Geohydrological systems and clusters of systems occur in various space and time scales (2); see also figure 2. Distinctions can be made between the following systems:

- Local systems: relatively small systems in which the infiltration and exfiltration area border each other. Travel times are short (do not exceed a few decades).
- Intermediate systems: relatively shallow systems (to around 50 metres below ground level) with at least one local system between the infiltration and exfiltration area.
- Regional systems: infiltration and exfiltration areas coincide with topographical high and low elevations and travel times range from decades to thousands of years.
- Supraregional systems: systems that extend across various regional water partitions; the infiltration area is in a topographically high area and the exfiltration area is in a large low-lying area. The groundwater flows to a great depth (> 100 metres below ground level and the travel times are very long (>1000 years).

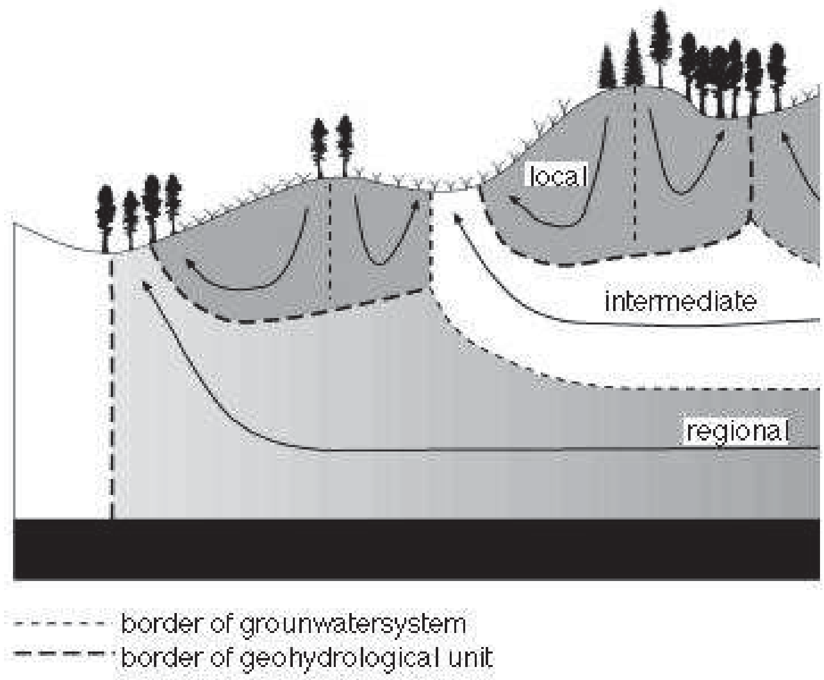

Figure 2. Diagram of groundwater systems and groundwater flow systems with a different spatial scale.

As mentioned earlier, geohydrological units consist of a collection of systems. These are local and intermediate geohydrological systems together with the entrance and/ or exit of (supra) regional systems. The entrance of a (supra) regional system is known as a core infiltration area and the exit of a (supra) regional system is known as a core exfiltration area. Examples of these areas are the Veluwe region and Beemster polder, respectively. The units do not by definition include the starting point and end point of (supra) regional systems. After all, it is proposed that infiltration and exfiltration should be seen as separate in these systems. Figure 3 shows a diagram of how groundwater systems may be situated in a geohydrological unit.

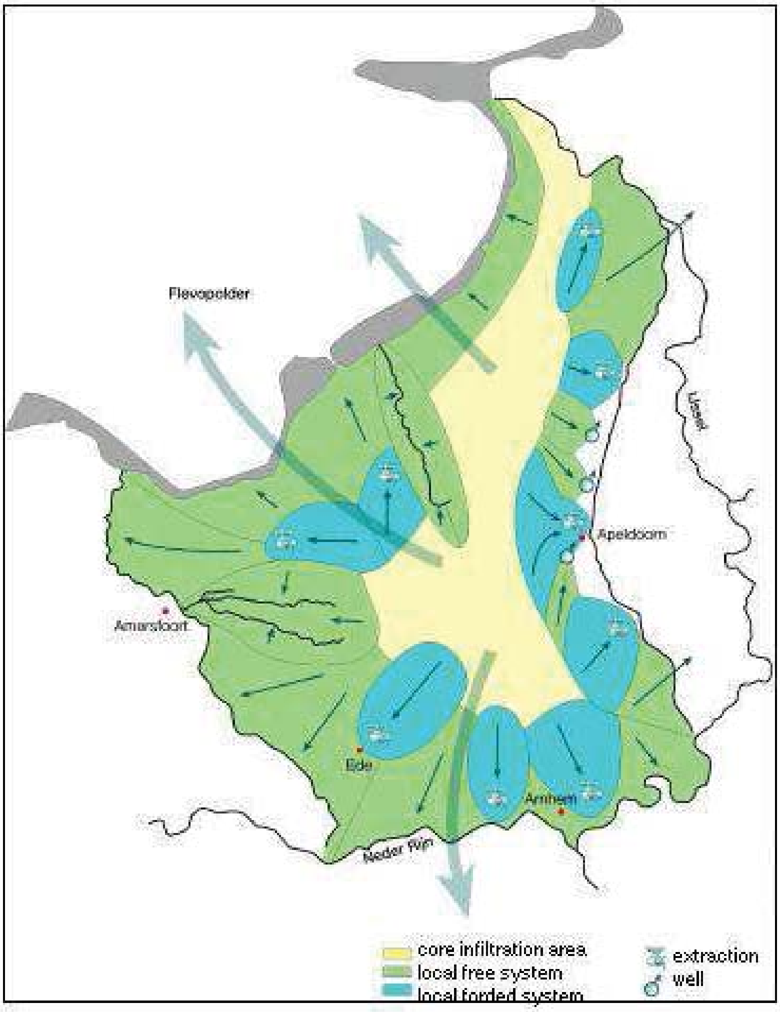

Figure 3. The groundwater body of the Veluwe river basin and its groundwater systems. A core infiltration area(yellow) is a large area in which the groundwater is taken to a large depth; a local free system (green) is a small-scale groundwater system in which the flow and the water table are more or less natural (unforced). A forced system (blue) is regulated

DEMARCATION IN TIME AND SPACE

The explanation of the scale classification shows that spatial scales and time scales are closely related. Groundwater travel times in (supra) regional systems are often longer (thousands of years longer) than those in local systems (up to a few decades). Therefore, it takes an exceptionally long time in very large groundwater flow systems for the result of an impact in a infiltration area to manifest at ground level. Within the scope of water management, the working group does not think it would be advisable to link groundwater systems in which the travel time from the infiltration area to the exfiltration area exceeds 30 years. The period of 30 years is normal as an horizon for specific planning. Even though 30 years is still extremely short in geohydrological time scales, for human measures, a management cycle of more than 30 years is long. The working group therefore suggests the following:

- In systems in which the water travel time is shorter than 30 years, the link should be maintained between effects in the exfiltration area and the impacts in the infiltration area. Management here is therefore specific for the entire geohydrological body. This means that the management objectives and considerations concerning measures to be taken depend on the predicted effects in the outflow area.
- Management of systems with travel times of longer than 30 years should not be geared to effects in the outflow area but should be based on a general, preventive protection principle.

Travel times of local and intermediate systems are generally shorter than 30 years. Therefore, in these systems, specific management can be applied that is based on feeding back the requirements set by ecosystems in the outflow area to the groundwater in the infiltration areas, with regard to those requirements that are related to the outflow area (or the requirements of groundwater abstraction for groundwater that is supplied from water catchment areas). The working group suggests a general management principle for regional and supraregional systems. This approach is worked out in greater detail in chapter 4.

The working group has mapped out the geohydrological management units for the Netherlands. A size was sought that met the stated criteria and that was comparable in terms of its order of magnitude with that of water control authorities. The background to this consideration was that the size of water control authorities reflects (even if indirectly) the considerations concerned with the required detail and, on the other hand, the effort required for the management. However, the boundaries of water control authorities did not form a criterion because the boundaries between water control authorities do not always follow the lines of hydrologically uniform partial river basins or geohydrologically uniform groundwater bodies. In fact, the boundaries also partly arose from cultural-historical developments. Figure 4 shows the working group's proposal for an area division for the Netherlands.

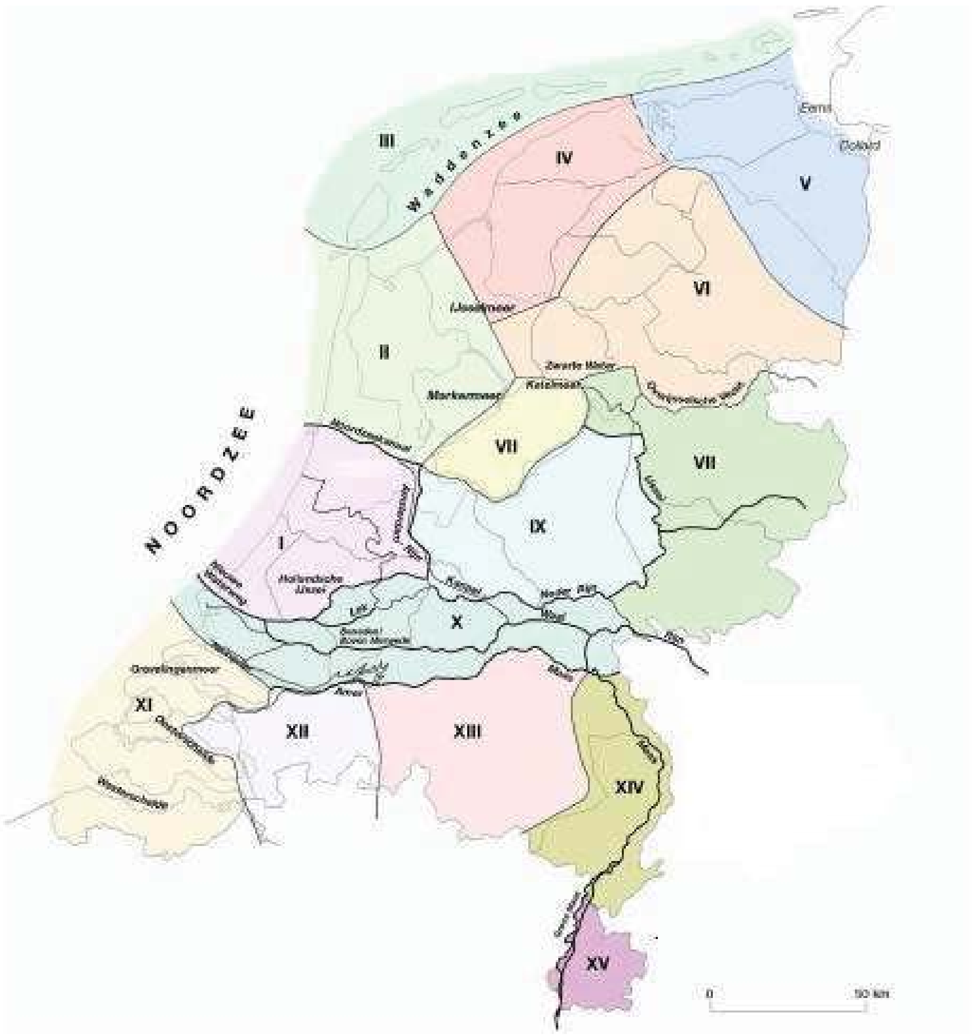

Figure 4. Division of the Netherlands into geohydrological management units.

Table 1 provides a brief explanation of the geohydrological management units that are recognised. The boundaries between the units should be seen as indicative because the units have been divided on the basis of general geohydrological and geographical information.

Table 1. Characteristics of the fifteen areas that have been identified with geohydrologically related groundwater bodies.

Area	Geohydrological characteristics
I. Central Holland	• The area is formed by low-lying polders as exfiltration areas and with peat grassland areas, ponds and the dunes as infiltration areas.
II. North Holland above the IJ	• The area is similar to area I but geographically separated from it.
III. West Frisian islands	• Geohydrological systems limited by islands.
IV. Frisian mud flats and lakes area	• Flat area with slight gradients and infiltration by seawater from the Wadden Sea.
V. Groningen/ Drents Plateau, Eems and Dollard	• Transition from eastern side of Drents Plateau to coastal zone of Eems/ Dollard to Wadden Sea, with different deep and shallow systems.
VI. Drents Plateau and North-East polder	• Drents Plateau as an infiltration area and exfiltration areas in stream valleys and polders. Deep groundwater systems are present with strategic fresh groundwater.
VII. Eastern Netherlands	• Infiltration in lateral moraines and, for example, wind-borne deposit areas with relatively shallow geohydrological systems through the presence of consolidated rock near the surface.
VIII. Flevo polders	• Polder with (supra) regional seepage and local polder systems.
IX. Central Netherlands lateral moraines and valleys	• Lateral moraines as infiltration area for local to (supra) regional systems with the small systems on the edges and dewatering through small rivers and streams.
X. Rivers and forelands	• Polder areas with riverbank filtration from Rhine, Waal and Meuse, as well as regional seepage from lateral moraines and local rainwater systems in the polders.
XI. Islands of Zeeland and South Holland	• Geohydrological systems limited by islands and seawater intrusion to low-lying polder areas.
XII. Western Brabant	• Free systems that drain into open waters in Zeeland. The shallow systems are fast and the deep systems are exceptionally slow.
XIII. Central Slenk and vicinity	• Infiltration from the high parts and drainage through small rivers and streams. Strategic groundwater stocks down to large depths and input from adjacent geohydrological foreign areas (Kemp Plateau, Peel, brown coal area).
XIV. Meuse valley and Peel	• Infiltration in high parts and exfiltration in the Meuse or short tributaries of the Meuse. Fast local and intermediate systems do not extend to great depths.
XV. Southern Limburg	• Area of consolidated sediments at or close to surface, with the unusual feature in the Netherlands of rapid groundwater flow in hard rock.

It is repeatedly proposed for the WFD's implementation that it should be in line with the indicative division into the partial river basins of the 21st Century Water Management Committee (3).

Figure 5. Indicative division of the Netherlands into river basins (3).

Figure 5 shows the division. Comparing figure 4 and figure 5 clearly shows that there are major differences:

- The seventeen partial river basins according to the Water Management Committee are aggregations of existing water control authorities, as opposed to the fifteen groundwater bodies that we have distinguished on the basis of geohydrological uniformity.

- The Amstelland partial river basin is a combination of various geohydrological/ hydrological homogeneous areas and, from the geographical and hydrological standpoint, is an area that displays no relationships.
- The extended Drents Plateau was parcelled out between various partial river basins in the division of the river basins. Part was added to the area of the province of Overijssel. This choice was not justified from the hydrological standpoint. The flooding that occurred at Meppel some years ago clearly shows that the Drents Plateau ought to be seen as a whole, whereas the area to the south of Vecht in Overijssel should be seen as a second unit. The North-East polder is hydrologically more related to the Drents Plateau than the other Flevo polders.
- The water divide between Eems river basin and the Rhine river basin runs across the Drents Plateau. This boundary should appear in the division. The eastward and northward moving drainage from the Drents Plateau intervenes more with the Eems river basin than with the Rhine river basin and there are also ideas about restoring the natural water system around the city of Groningen. This would result in the eastern streams from the Drents Plateau flowing into the Wadden Sea and the boundary between the Eems and Rhine river basins having to lie near Lauwers lake.
- Looked at over the course of a year, the IJssel river drains up to Deventer and infiltrates from Deventer to Ketel lake. There is therefore no reason to include the eastern part of the Veluwe region in two partial river basins (Veluwe and Achterhoek). Considering that it is difficult to draw a water divide in the Veluwe region, it is also better to draw the western and eastern Veluwe together to form a partial river basin, together with the ridge of hills known as the Utrechtse Heuvelrug. The existence of large groundwater abstraction points has a major impact on groundwater flow directions and drainage in the Veluwe region, so there is no permanent water divide.
- Salland, Twente and the Achterhoek regions display close hydrological relationships and could be drawn into a single partial river basin.
- The river area from Nijmegen to Hoek van Holland can be considered as a single hydrologically homogeneous area, where riverbank filtration from the large rivers plays a major role.
- It would be advisable to divide Brabant and Limburg into three units: 1) the area of western Brabant, from which both groundwater and surface water generally drain into the open water in the delta area and which can be clustered below the Schelde river basin, 2) the area that drains through the Brabant streams into the Meuse, which is infiltrating, and 3) the area that directly

(seepage in the river) or indirectly (drainage through small tributaries) drains into the Meuse, which is generally a draining river up to Grave.

The management scale of the two divisions is similar and is of the first level in the order of the river basins of the large rivers. The geohydrological units have been made as large as possible, without introducing hydrologically heterogeneous units.

For administrative reasons, it may be advisable to opt for smaller management units in a few cases. Examples include the division of the Veluwe region and the ridge of hills known as the Utrechtse Heuvelrug into two units, or the division of the eastern Netherlands into two units that roughly correspond with the provincial boundaries. It may also be advisable from the administrative point of view to make a provincial distinction between the West Frisian Islands, and also between the islands of Zeeland and South Holland.

In conclusion, the area division into geohydrological management units provides substantial advantages vis-à-vis the indicative division of the Netherlands into partial river basins. The working group recommends adopting the geohydrological division shown in figure 4.

OPTING FOR A SCALE INCREASE OR SCALE REDUCTION

The proposed division into management units provides a general, indicative demarcation. In specific situations, it will be advisable to depart from the general unit and to opt for a larger or smaller management unit. Whether such a situation arises will be determined by the properties of the water system being managed and by the specific activities that have an impact on the systems. If the situation arises, it will have to be possible to perform the management activities on the basis of a more detailed or, as the case may be, more general scale.

The following determining factors play a role in the process of switching to larger or smaller scales:
1) the extent of the effect of the impacting activities;
2) the 'hydrological space requirements' of groundwater functions;
3) the integration of flow path management and hydraulic-head management.

Re 1

The angle of approach here is the impact. In principle, management is relevant at the scale at which the impact on groundwater affects the groundwater body. If a groundwater abstraction point results in drought problems on a scale of some tens of kilometres, management limited to a part of the affected area is insufficient. An extreme example of groundwater level reduction that has to be evaluated and monitored over a very large area is the effect that brown coal mining at Aken, in Germany, has on the groundwater level in Limburg and North Brabant, in the Netherlands. The working group thinks it would be inadvisable in such a situation for management to only focus on small parts of the affected system. With this, the groundwater level reduction would incorrectly be viewed as an autonomous process that could not be influenced. Scaling up management is a precondition for tackling trans-border problems. In most cases, trans-border management is generally more relevant in relation to the spreading of pollutants for surface water rather than for groundwater (e.g. the quality improvements in the Rhine, Meuse and Schelde). However, trans-border management is relevant for maintaining groundwater flow directions.

Re 2

Use is the angle of approach here. A general criterion concerning the use of management measures for groundwater bodies is to achieve the objectives for which the groundwater is used. As indicated in chapter 1, besides user interfaces for people, this is also concerned with groundwater in relation to aquatic and terrestrial nature. Further demarcation may be required for management because the hydrological space requirements of a nature reserve or a function for human use do not always correspond with the geographical area division according to figure 4. The further demarcation can be made by dividing a geohydrological management unit into its component parts, such as individual (local or intermediate) systems. However, the geohydrological relationships still determine the approach for demarcation of this kind on a larger or smaller scale.

Re 3

In the case of integrating flow paths and hydraulic heads in river basin management, it is extremely important to recognise that both aspects have a different scale in both space and time. Water management and geohydrological interventions, such as setting up a different polder level or installing a groundwater abstraction point, result in a change in hydraulic heads over a period of weeks to years. In exceptional cases, the reaction time may be longer[15]. The time scale of spread effects is longer by orders of magnitude.

It is not possible to state any general rule of this kind for the spatial scale. Roughly speaking, it is possible to say that hydraulic head effects have a broader effect than those of the flow path effects. A groundwater abstraction point leads to water transport and substance transport in an area that is designated as the water catchment area. The protection of the abstraction point against pumping up polluted water covers at the most the water catchment area (12). The abstraction leads to a reduction in the groundwater level. However, the reduction of the groundwater level occurs in a much larger area than the actual water catchment area. Measures to combat loss of wetlands caused by groundwater abstraction therefore cover a larger area than water catchment area.

CONCLUSIONS AND RECOMMENDATIONS

The working group recommends appointing groundwater bodies on the basis of uniformity in their geohydrological location. A groundwater body defined in this way covers an area that includes several groundwater systems that respond in a similar way to influences. These bodies generally consist of local and intermediate systems and either the starting point or the end point of (supra) regional systems.

Initially, the required scale level of the spatial demarcation of the bodies is the order of magnitude of that of the water control authorities. However, the division is not the same as the boundaries of water control authorities and also differs in essential respects from the indicative proposal of the 21st Century Water Management Committee. Taking the working group's approach, 15 areas are recognisable in the Netherlands.

15 With the impoldering of the Flevo polder, which was an extremely large-scale water management intervention, it was around 30 years before the entire groundwater flow system had adapted to the new hydrological situation (11).

In systems in which an impact is detectible at ground level in the infiltration area within 30 years, it is advisable and, in terms of management, possible to maintain the link between effects in the exfiltration area and influences in the infiltration area. In these cases, management therefore covers the entire geohydrological system and depends on the system's functions. In systems in which the effect manifests more than 30 years later, the general management principle can be used.

However, by way of departure from this, it must be possible to opt for management on a larger or smaller scale, if this is necessary on account of:

- the extent of the effect of the impacting activities;
- the 'hydrological space requirements' of groundwater functions;
- the integration of flow path and the quality aspects related to the hydraulic head;

4 The good status of groundwater and the starting point of reversal

The WFD defines a 'good status' for quantitative and qualitative aspects. This chapter is concerned with working out the good status and the starting point of reversal in the WFD's implementation. Good status is concerned with the question of which environmental result has to be achieved through management. The starting point of reversal is concerned with the question of which situation in the environment gives cause for taking management measures.

The actual definitions are provided below of the quantitative good status and qualitative good status, as indicated in the WFD. Quantitative good status is described as follows (quotation):
'The level of groundwater in the groundwater body is such that the available groundwater resource (this refers to groundwater replenishment[16], ed.) is not exceeded by the long-term annual average rate of abstraction. Accordingly, the level of groundwater is not subject to anthropogenic alterations such as would result in:

- failure to achieve the environmental objectives specified under Article 4 for associated surface waters;
- any significant diminution in the status of such waters;
- any significant damage to terrestrial ecosystems which depend directly on the groundwater body

and alterations to flow direction resulting from level changes may occur temporarily, or continuously in a spatially limited area, but such reversals do not cause saltwater or other intrusion, and do not indicate a sustained and clearly identified anthropogenically induced trend in flow direction likely to result in such intrusions.'

Good groundwater quality is defined in the WFD as 'the good chemical status'. This is defined as follows (quotation):

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16 Available groundwater resource is defined as 'the long-term annual average rate of overall recharge of the body of groundwater less the long-term annual rate of flow required to achieve the ecological quality objectives for associated surface waters specified under Article 4, to avoid any significant diminution in the ecological status of such waters and to avoid any significant damage to associated terrestrial ecosystems.'

' The chemical composition of the groundwater body is such that the concentrations of pollutants:

- as specified below (in the annex of the WFD, ed.), do not exhibit the effects of saline or other intrusions;
- do not exceed the quality standards applicable under other relevant Community legislation in accordance with Article 17;
- are not such as would result in failure to achieve the environmental objectives specified under Article 4 for associated surface waters nor any significant diminution of the ecological or chemical quality of such bodies nor in any significant damage to terrestrial ecosystems which depend directly on the groundwater body.

Changes in conductivity do not indicate saline intrusion or the intrusion of other substances into the groundwater body.'

GENERAL COMMENTS

Good status, as defined in the WFD, is mainly concerned with the situation of ecosystems that are dependent on groundwater. Unlike in the case of surface waters, in the case of groundwater, no attention is paid to the ecological condition of groundwater. The working group stresses that groundwater should not only be considered on the basis of the relationship to other systems but also as independent ecosystems. Even in the case of systems that cannot be directly related to specific functions, maintenance or recovery is advisable.

The working group believes that, in view of the importance of integrating quality and quantity, the term ‘good status’ should not be seen purely in terms of substance-based effects. Therefore, this chapter also discusses physical and biological aspects. Chapter 2 concluded that quality and quantity in river basin management should be integrated. This view forms the starting point for this chapter's recommendations on good status.

RECOVERY AND MAINTENANCE BASED ON PRECAUTIONS

The chemical as well as physical impact on groundwater systems is considerable in the Netherlands, owing to the intensive use made of the soil and groundwater. The chemical impact has resulted in increased concentrations of heavy metals and organic compounds, such as pesticides, in the groundwater. The physical impact has resulted in increased abstraction, reduced groundwater replenishment in infiltration areas, owing to rapid surface drainage, and a low seepage pressure because of drainage. The WFD's aim is the maintenance and recovery of water systems. Directly in line with this aim:

- the present situation, which has arisen because of a period of intensive physical and chemical pressure as a result of human activity, can be considered as a suitable starting point of reversal;
- the natural starting situation can be considered as a starting point for determining the good status in the chemical, physical and ecological sense.

The working group sees this interpretation of the directive as a basic guideline for the objective of river basin management, based on 'precaution'.

A confrontation of the precautionary principle with the present condition of groundwater systems in the Netherlands and the way in which groundwater is used makes it clear that some nuances are necessary:

- Groundwater pollution is a fact in the present situation,. Chapter 2 already pointed out how slowly systems react in many cases to impacts. Recovery of groundwater systems in which the quality has deteriorated as a result of chemical anthropogenic impacts practically always takes a long time; often decades. Recovery within the foreseeable future to the level of the natural starting situation is practically impossible for groundwater systems with a recovery period of this length.
- Not only is pollution caused by impacts in the past a fact, groundwater use and the impact on groundwater are also accepted now, within certain limits. Groundwater is now allowed to be used in a certain extent as a filter and break-down medium. This means that some impact on groundwater is permitted, because the system has a cleansing ability. (Consider the fact that the allowance of pesticides is related to occurrences at ten metres below ground level and to taking into account nitrate conversion when determining acceptable nitrogen losses.) A preventive angle of approach that focuses on systems that have not been subject to any impact will not provide any adequate starting points for management.
- Some systems have arisen through human activity. No natural starting situation can be determined for these systems.

Therefore, instead of this, the working group suggests drawing up coherent rules for dealing with groundwater. The precautionary principle should provide the general direction for this.

SPECIFIC AND GENERAL QUALITY MANAGEMENT

A distinction was made in chapter 3 between groundwater systems with groundwater travel times that are shorter than 30 years and systems with travel times that are longer than 30 years. The following can be added to this distinction when working out the good status:

1) in systems with water travel times that are shorter than 30 years, the relationship to surface water and terrestrial systems and functions for human use is the determining factor for working out the good status;
2) in systems with travel times that are longer than 30 years, the groundwater ecosystem itself should be considered as an object that requires protection; the good status is worked out with a general, preventive effect for this purpose.

Ad 1) Relationships to aquatic and terrestrial systems and functions

The good status can also be specified on the basis of the relationship of groundwater bodies to groundwater-dependent ecosystems or on the basis of human-related uses.

Because surface water management (also in the WFD) focuses on achieving an ecologically good status, ecological aspects should also be taken into account in the case of groundwater. For those situations in which groundwater feeds the surface water, this can be achieved by adopting the water system approach that applies to surface waters. In this approach, substance-based standards are only one component, alongside physical, morphological and ecological system properties. The required status in surface water can be translated into that required for groundwater on the basis of the hydrological relationship between groundwater and surface water.

For terrestrial ecosystems, there is no similar framework to the water system approach. Nevertheless, a lot is known about the reaction of terrestrial nature to changes in groundwater quality (12), so, in this case too, it is possible to determine a good status for groundwater on the basis of hydrological and ecological information.

Ad 2) Groundwater as an object that requires protection

A general protection principle should be applied to occurrences of groundwater that have no direct relationship to groundwater-dependent systems and that do not fulfil any specific functions. To this end, unlike in the case of 'related groundwater bodies', a system-orientated approach need not be adopted.

The general protection should be geared to the general functions the groundwater always fulfils. Chemically and biologically catalysed reactions occur in groundwater, which form part of various biochemical cycles, such as the carbon and the nitrogen cycle. Moreover, groundwater is host to characteristic biocoenoses that have a high value from the point of view of biological diversity. Finally, groundwater forms a strategic stock and its quality is important in terms of future functions.

The protection should also take into account the vulnerability of groundwater systems and processes in groundwater. Because biological activities take place slowly and because groundwater generally has a low buffering capacity, groundwater ecosystems are sensitive to outside influences. It is difficult to say when biogeochemical cycles are disturbed. However, recovery is slow, particularly in groundwater systems with long travel times. Therefore, an impact results in a more or less irreversible deterioration in quality.

The working group therefore suggests that the protection of groundwater systems of this kind should be grafted onto a preventive angle of approach and should be based on the natural starting situation. In these occurrences of groundwater, the management should focus on structurally influencing groundwater bodies in the future. This means that the quality improvement should take place in the groundwater replenishment. In systems of this kind, it is less effective to pay a lot of attention to the status, insofar as it has arisen because of an impact in the past. The lag of pollution that is already present is then a fact. This means that the management of riverbanks by means of Rhine water infiltration focuses firstly on the quality of the Rhine water and only secondly on the quality of the water that has already infiltrated.

Table 2 shows how good status works out for systems with short and systems with long travel times.

Table 2. Management principle for groundwater systems with a reaction times that are quicker and slower than 30 years.

Reaction time	Starting point	Point of action for management	Starting point of reversal	Good status
< 30 y	Specific management	Whole system	Relate to effects and risks	Follows from system approach
> 30 y	General, preventive management	Groundwater replenishment	Present levels, if higher than the natural background	Determine acceptable impact from the natural starting situation

The directive stipulates that the good status in water systems must have been achieved by 2015. Because of the slow recovery rate of many of the water systems in the Netherlands, this cannot be achieved in all cases. However, this will be feasible within the stipulated period for some systems with a rapid recovery rate. In cases where this is advisable from the policy point of view, the working group suggests considering determining in which systems it will be possible to aim for recovery of the entire body by 2015 and in which systems groundwater replenishment can achieve the level of the good status within this period. The recovery rate of systems can then be ordered according to spatial scales. For groundwater management, a period of up to 2015 is rather short. The working group would prefer to think in terms of a period of 30 years.

STANDARDISATION

Owing to the specific character, the role of using sets of standards in river basin management is less pronounced than in the case of soil management. In particular, the hydraulic head aspects of groundwater management are so specific and so dependent on groundwater bodies and on soil and groundwater use in related systems that it is not worthwhile developing a general set of standards for this. Preparations are currently underway at the provincial level for drafting targets for the required groundwater situation (GGOR[17]). The working group suggests considering taking part in this, but stresses that it considers it extremely important that the hydrologically required groundwater situation for individual groundwater bodies should be interrelated with other quality aspects (see also the discussion above in chapter 2).

However, general standards can play an important role in determining the good status of groundwater replenishment (as part of the general protection policy). The

[17] Required Groundwater and Surface Water Regime.

working group suggests, in line with the directive's precautionary approach, that the maximum acceptable substance impact should, in due course, be make the same as the impact that corresponds with natural situations. This approach will lead to standards for the quality of groundwater replenishment. These will mainly have to be interpreted in terms of a lower atmospheric deposition (of heavy metals, for example) and a lower supply of substances via river water that infiltrates into riverbanks.

DETERMINATION OF TRENDS

For situations in which the general protection applies, protection focuses on groundwater replenishment. According to our proposals, if the present impact on groundwater systems is significantly higher than the impact in natural situations, source-based measures should be taken. In these situations, it is not necessary to detect a trend in increasing impact in order to determine a reversal starting point. This approach leads to a considerable simplification of decision-making. Certainly for groundwater replenishment, it is possible to determine whether the impact has increased significantly with respect to natural levels in the groundwater replenishment.

It is much more difficult to determine a trend of increasing concentrations in the entire groundwater body. This involves performing specific management for small systems. An accumulation of variabilities and measurement errors makes it complicated to reliably demonstrate trends. This is connected with issues such as the variabilities between systems, variabilities in impact in time and space, variabilities of environmental conditions, such as excess precipitation, and variabilities at the micro scale that limit a single sample's representativeness for the environment. This therefore requires making as much use as possible, in the specific management, of data on the impact on systems, rather than simply analysing systems as a whole. The question of whether a change is advisable can be answered on the basis of trends in the pressure on the systems. The question of how the systems should be restored will have to be answered on the basis of investigations carried out in the actual groundwater systems.

RECOMMENDATIONS

The working group recommends the precautionary approach as the elementary guidelines for giving shape to the good groundwater status and the starting point of reversal.

When working out the details, the working group recommends making a distinction between:

- the good status in relation to aquatic systems, terrestrial systems and human use, and
- the good status in terms of the actual groundwater.

The working group recommends that the good status should not be precisely established in advance and that it should be recognised that the systems to a large extent determine which status is required. Deciding which of the protection principles takes precedence, which components of the system are relevant for management and the period within which results should be achieved therefore depends on the systems that are being managed.

The working group suggests the following for systems with travel times of more than 30 years:

- the management should be generally preventive;
- the point of action for management should be groundwater replenishment;
- the present levels should be the starting point of reversal, if they are higher than the natural background;
- the good status should correspond with a groundwater replenishment quality that is the same as that of the natural background.

The working group suggests the following for systems with travel times that are shorter than 30 years:

- the management should be specific;
- the point of action for management should be the entire system;
- the starting point of reversal should be derived from the effects and risks in the system or in the environment that is affected by the system;
- the good status should also be derived from the effects and objectives that have to be determined.

5 MONITORING

The WFD points out that implementing river basin management necessitates monitoring the following:

- the chemical status of groundwater and of anthropogenic trends;
- hazardous situations or developments.

The issue of monitoring is assessed using the following two angles of approach:

1) What is the optimum set-up for a monitoring network used for river basin management?
2) Are the present monitoring programmes adequate?

THE OPTIMUM MONITORING STRATEGY

The working group believes the following conditions should be taken into account when setting up the monitoring system for groundwater bodies:

1) Monitoring should support the aspects of management concerned with integration of the flow path and hydraulic head.
2) Measuring networks for monitoring should correspond with the scale at which the management is performed and should be specifically based on the parts of groundwater bodies that are relevant for management.
3) Monitoring's primary function is to provide information on developments.
4) Monitoring should support feedback on the use and impact of soil and groundwater and vice versa.

Significance for monitoring strategies

<u>Re 1</u>

For setting up monitoring programmes, this means that monitoring should be linked to geohydrological models. In many cases, this should include information on hydraulic heads and flow paths. This is particularly important because models provide a context to which measurement data can be related. The working group considers this link important in both the design of a monitoring programme and in data interpretation.

<u>Re 2</u>

In chapter 3, on the scale of groundwater bodies, the working group distinguished between 'slow' groundwater bodies that flow to a great depth and groundwater bodies in which a link can be made to groundwater-dependent systems and functions for human use. For the first group, management focuses on good chemical quality for groundwater replenishment. Monitoring should make it possible to determine whether that influencing of the groundwater replenishment is actually sufficient. This has to be measured in the first influenced part of a groundwater body. It is not worthwhile sampling substances in part of a groundwater body that cannot yet be influenced. It is also not worthwhile determining an average of concentrations over the entire groundwater body, if a known stratification/ clearly demonstrable area of influence exists. If a stratification is not based on slowness but on an ongoing process of decomposition, it is obviously advisable to make measurements at different depths so that the substance's decomposition can be monitored.

In the case of the second group of groundwater systems that require specific management, the entire body may, in principle, be relevant. The way in which systems of this kind should be monitored depends on the specific aspects, such as the groundwater body's relationship to the ecosystems that depend on it, the level of pollution in the body, and the sensitivity to changes in hydraulic head.

Re 4

Particularly in rapidly reacting groundwater bodies that are clearly connected to other systems, the set-up of a measuring network for monitoring should not be of a fixed design. To achieve the feedback referred to in the fourth of the aforementioned conditions, it may be necessary to modify the set-up on the basis of previously collected measurement data or in response to a change in soil use or a different hydrological situation. The modification may concern the measuring frequency as well as the measuring density and the parameters that have to be determined. It is worth stressing that a decision based on collected information need not only concern intensification or more specific measurements being taken. Measurements in groundwater bodies may also indicate that it would be accountable to make monitoring programmes less extensive.

General

Involving geohydrological information in the design of monitoring programmes will also be a determining factor for the density of monitoring networks, the location of monitoring points, the parameters to be determined and the frequency of measurements. The level of aggregation of measurement data equates with the scale at which groundwater bodies are managed. The scale of groundwater management units can be the criterion for this. The working group is unable to say at this point how measurement data ought to be aggregated.

THE PRESENT MONITORING PROGRAMMES

The chemical aspects of groundwater are currently structurally monitored in the National Groundwater Quality Monitoring Network (LMG), the Provincial Groundwater Quality Monitoring Networks (PMGs) and (specifically for nitrate) the National Monitoring Network for Fertilizer Policy (LMM) (13). These monitoring networks are not specifically intended to be used for supporting river basin management. The conditions that the working group indicated at the start of this chapter are therefore not determining for the existing design and set-up. Besides the aforementioned structural monitoring of chemical quality, many incidental measurements are also made within the scope of specific projects. Finally, groundwater levels in the Netherlands are regularly determined for practically the whole country. In many cases the existing monitoring programmes do not meet the monitoring conditions in river basin management. In particular, the feedback between soil use, impacts in systems and management measures is absent. Moreover, no link has been included between the monitoring programmes and the envisaged systems for groundwater bodies.

The working group is convinced that a need will arise in river basin management for additional measurement data, especially for situations in which groundwater bodies are managed in a specific manner. However, it is difficult to say in advance which points of the existing measurement data from the structural and incidental programmes will be inadequate.

The WFD stipulates that a monitoring network must contain 'sufficient representative monitoring points to estimate the groundwater level in each groundwater body or group of bodies'. Taking the division into partial river basins that we have proposed, average data are available for each area from approximately 40 monitoring points in the LMG. This may well be sufficient for large infiltration systems, in which only groundwater replenishment needs to be monitored. Systematic measurements are made in the shallow groundwater as part of the LMG and PMG. At first sight, this is in keeping with the management of systems of this kind.

However, the working group believes it is not worthwhile making generally definitive statements about this. A pilot project in one or more of the proposed areas with geohydrological relationships should make the extent of additional data requirements clear. A similar project was carried out in 1999, in the Hunze river basin (14). The study focused specifically on examining what the organisational consequences would be of WFD's implementation in that area, in terms of, amongst other things, the required monitoring work. Although, at that stage, the WFD had not yet been finalised and there was not much clarity about the lines along which implementation would take place, the study provided important information.

The working group is not calling for the simple modification of national monitoring networks because:

1) given the purpose for which they were established, the monitoring networks work extremely well;
2) for long-term developments, it is important not to quickly convert the existing monitoring networks or to end them.

Therefore, the working group would prefer to examine whether and to what degree river basin management requires additional monitoring and to obtain as much information as possible from existing monitoring networks.

CONCLUSIONS AND RECOMMENDATIONS

The monitoring requirements will have to be indicated by system-oriented river basin management. The general conditions that monitoring will have to meet are:

- monitoring must support the integration of the aspects concerned with the flow path and hydraulic head and must be in line with geohydrological models;
- the measuring networks for monitoring must be in line with the management scale;
- monitoring must provide information about developments;
- monitoring must make it possible to relate the impacts of soil/ groundwater use to the quality of groundwater and surface water.

Although the present monitoring networks were not set up for river basin management, it is likely that it will be possible to use parts of the present monitoring networks for river basin management. It is unlikely that the present monitoring networks will suffice in all respects. However, caution will be necessary in modifying the present monitoring networks because it is necessary to guard against breaking any 'trend information'.

It will be possible to examine how useful the existing monitoring networks are on the basis of a system-oriented analysis, but then applied to one or more partial river basins.

6 RECOMMENDATIONS

EXPLANATION OF THE RECOMMENDATIONS

The Water Framework Directive (WFD) is intended to coordinate water management in the various member states. The coordination should ensure that water management is made more coherent. This refers to the relationship between surface water management and groundwater management and the relationship between quality and quantity. Coherence has to be achieved by organising management into river basins. These are areas that drain water through channels, rivers and streams to a single estuary.

The following recommendations address the question of how the WFD can best be implemented in the Dutch situation, taking into account the:

- importance of integrating quality and quantity for the Netherlands;
- special geohydrological characteristics;
- intensive use made of the soil and water
- present management practice.

RELATIONSHIP BETWEEN QUALITY AND QUANTITY

In the Netherlands, a distinction is made between quantitative water management and qualitative management. Quantity is thought of in terms of surface water levels, abstraction areas and groundwater levels. Quality is thought of in terms of the impact of pollutants on the soil/groundwater system. The working group recommends that the interrelationships between the quantitative and qualitative aspects should be worked out for each river basin. Management should focus on quality. Quantity is mainly seen in terms of its influence on quality.

SCALE OF GROUNDWATER BODIES

When organising management, it is necessary to determine the scale of management that should be adopted and where the boundary should lie between the groundwater bodies that have to be managed.

The working group recommends dividing the Netherlands into groundwater bodies with a more or less equal geological and hydrological situation. The groundwater

bodies (these being demarcated areas) contain groundwater systems that display a comparable reaction to influences.
The working group has worked out a division on a map and recommends using this division. This results in 15 groundwater bodies in the Netherlands. The groundwater bodies are approximately as big as water control authorities. However, the boundaries of the groundwater bodies differ from the boundaries of the water control authorities and also differ from the indicative proposal of the 21st Century Water Management Committee.

Small groundwater systems, in which an impact is detectible at ground level within 30 years, can be managed as a whole. The management in the system's infiltration area must be geared to effects that manifest in the exfiltration area. Large systems, in which an impact is detectible over a longer period are generally not relevant for specific management. Quality has to be safeguarded there by preventive, general management of groundwater replenishment in the infiltration area.

DEFINITION OF THE GOOD STATUS AND THE STARTING POINT OF REVERSAL

The question in the organisation of the management is concerned with which environmental result has to be the target (what is the good status) and which status in water systems gives cause for taking measures (what is the starting point of reversal).

The working group recommends that the target in groundwater management should be the natural starting situation, except when practical circumstances prevent this. In systems under pressure, this means that the present situation under pressure is also the point at which it may be decided to take measures.

When working out the good status the working group recommends making a distinction between:

1) the good status in relation to aquatic systems, terrestrial systems and human use and
2) the good status in terms of the actual groundwater.

The working group recommends that the good status should not be precisely established in advance and that it should be recognised that the systems to a large extent determine which status is required. Deciding which of the protection principles takes precedence, which components of the system are relevant for management and the period within which results should be achieved therefore depends on the systems being managed.

The working group suggests the following for systems with travel times of more than 30 years:

- the management should be generally preventive;
- the point of action for management should be groundwater replenishment;
- the present levels should be the starting point of reversal, if they are higher than the natural background;
- the good status should correspond with a groundwater replenishment quality that is the same as that of the natural background.

The working group suggests the following for systems with travel times that are shorter than 30 years:

- the management should be specific;
- the point of action for management should be the entire system;
- the starting point of reversal should be derived from the effects and risks in the system or in the environment that is affected by the system;
- the good status should also be derived from the effects and objectives that have to be determined.

MONITORING

The question in the organisation of the management is concerned with how to check whether the management is being performed as required.

The monitoring requirements will have to be indicated by system-oriented river basin management. The general conditions that monitoring will have to meet are:

- monitoring must support the integration of the aspects concerned with the flow path and hydraulic head and must be in line with geohydrological models;
- the measuring networks for monitoring must be in line with the management scale;
- monitoring must provide information about developments;
- monitoring must make it possible to relate the impacts of soil/ groundwater use to the quality of groundwater and surface water.

The present monitoring networks were not set up for river basin management. The working group therefore recommends conducting system-oriented analysis, but then applied to one or more partial river basins, to examine the extent to which extra monitoring is required, in addition to the existing monitoring networks.

The working group recommends caution in modifying the present monitoring networks because it is necessary to guard against breaking any 'trend information'.

7 References

1. Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy.

2. TCB Groundwater Working Group, Systeemgericht grondwaterbeheer; Beschrijving van het functioneren van grondwatersystemen. (in preparation)

3. Brink, C. van den, J. Verloop & W.J. Zaadnoordijk, 2000. Sustainable Groundwater Management, in: Contaminated Soil 2000, Vol. 2, pp. 1448-1455.

4. Stuurman, R.J. 1.500.000 jaar lang veranderingen in de lokale grondwatersituatie van een Kempens beekdal. TNO report NITG 98-53-B.

5. Griffoen & Stuurman. Praktijkgevallen van grondwaterbeheer; case study. (in preparation)

6. Rossum, P. van, Verspreiding van arseen in de bodem en het grondwater van de provincie Noord-Holland, onderzoeksrapport met hypothesen over de herkomst en het mobilisatiemechanisme, 1996. Faculty of Geo-Sciences, hydrology section, Free University of Amsterdam, ISBN nr. 90-75739-01-X.

7. Lamers, L.P.M., 2001. Tackling Biogeochemical Questions in Peatlands (doctoral dissertation, Nijmegen University).

8. Advies Hoge gehalten aan van nature voorkomende stoffen, 2000. TCB S52(2000), Soil Protection Technical Committee, The Hague.

9. Wijland, R, 1996. Diepe ondergrond en bodembescherming, 1996. TCB R06(1996), Soil Protection Technical Committee, The Hague.

10. Waterbeleid voor de 21^{e} eeuw; advisory report of the 21st Century Water Management Committee. August 2000.

11. Gehrels, J.C., 1999. Groundwater level fluctuations, Separation of natural from anthropogenic influences and determination of groundwater recharge in the Veluwe area, the Netherlands. Doctoral dissertation, Faculty of Geo-Sciences, Free University of Amsterdam.

12. Advies Aanvullende grondwaterbescherming tegen diffuse bronnen van bodemverontreiniging, June 1991. TCB A91/06, Soil Protection Technical Committee, The Hague.

13. Fraters, B., M.M. van Eerdt, D.W. de Hoop, P. Latour, C.S.M. Oltshoorn, O.C. Swertz, F. Verstraten & W.J. Willems, 2000. Landbouwpraktijk en water-kwaliteit in Nederland, Achtergrondinformatie periode 1992-1997 voor de landenrapportage EU-nitraatrichtlijn, RIVM report 718201003.

14. Groenewolt, A, J.-S. Rus and S. Busch, 1999. Rivier Actie Programma; Effecten van de Kaderrichtlijn Water voor het Hunzestroomgebied, RIZA report 99.070, ISBN 9036952956.

ANNEX I: THE COMPOSITION OF THE GROUNDWATER WORKING GROUP

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