III Groundwater characterization

1 Introduction

The particularity of the Water Framework Directive is that it does not consider groundwater only as something that can be exploited by man, it also acknowledges the important role played by groundwater in the overall water cycle, i.e. in the relationship to surface water and, in general, in relationship to the biosphere.

As a result, as from today, the consideration of quantitative and qualitative aspects of groundwater must include all aquifers, including the layers that are not being exploited yet because of their low productivity or because another natural resource is being exploited.

There is definitely no lack of water in the Scheldt IRBD, but it is subjected to heavy human pressure. It is therefore important to make sure that the water quality does not deteriorate. Here, we must take into account the fact that groundwater has a greater inertia than surface water.

The main hydro-geological aspects to be taken into account in our assessment of the risk that groundwater would fail to achieve the good status are:

- the permeability of the aquifer (whatever the scale!);
- the geometry of the aquifer;
- the vertical position of the aquifer and the level of coverage (confined or free);
- the way in which the aquifer is recharged;
- the exchange between aquifer and surface water.

The purpose of the information in this chapter, regarding groundwater, is meeting the requirements of article 5 of Directive 2000/60/EC concerning the analysis of the characteristics of the Scheldt IRBD. The procedure to be followed when carrying out this characterization of groundwater is explained in further detail in section 2 of Annex II of the Directive.

Hereby, we must stress that, in the present case, we mainly focused on a so-called 'initial' characterization, because we still lack a lot of data at present (or just the analysis of these data) for a so-called 'further' characterization.

The purpose of the initial characterization is determining 'immediately', often on the basis of expert judgement, which groundwater bodies are at risk of failing to meet the objectives established in article 4 of the Directive by 2015.

If so, a more detailed characterization must be carried out for those groundwater bodies that are at risk. However, the level of reliability required during this assessment of the 'risk of failure' is not specified.

Therefore, it seems inevitable that this procedure will lead to huge differences in interpretation of the concepts between the different member states or regions, as well as to major differences in reliability between the assessments of the different groundwater bodies according to the available knowledge. This is one of the reasons why some partners have pronounced no opinion yet on the risks for some groundwater bodies or, to put it crudely, why they consider any groundwater body that is not sufficiently known as 'at risk'.

Moreover, it is a fact that the assessment of the risk is based on objectives to be reached, but as these objectives have not been established clearly yet, this reinforces even more the difference between the results. More definite provisions should follow the publication of the present Groundwater Directive but, unfortunately, they were not available yet when this report was drawn up.

As a result, within the framework of the Scaldit project, we had to produce special efforts to attune and harmonize the information demanded by the Directive. Most information was collected according to a common format in an Access database, which was updated continuously during the international coordination of the district.

We focused specifically on the transnational groundwater bodies, because according to paragraph 2.3. in Annex II, for these groundwater bodies, a more detailed assessment of the effects of human activities must be carried out.

2 Delineation and general characteristics of the groundwater bodies

2.1 Map of the groundwater bodies

Maps 9, 10 and 11 show the delineation of the groundwater bodies in the Scheldt IRBD, as it exists today. In order to give a better view of the different groundwater bodies on top of each other, we distinguish three levels (I, II and III). They include aquifers that belong respectively to the Oligocene-Holocene, Palaeocene-Eocene and Palaeo-Mesozoic basement.

Unlike for surface water, the guidance document "Identification of water bodies" gives few recommendations concerning the way in which groundwater bodies can be delineated, because the strictly physical boundaries are much more difficult to establish in groundwater than in surface water.

Therefore, each member state could freely decide on the typology to be chosen for groundwater. In principle, the definition, and the resulting delineation of groundwater bodies must follow only one single criterion: the quantitative and chemical status of the groundwater body concerned must be described as accurately as possible.

For this reason, and because the extent to which the delineation of groundwater bodies has progressed varies greatly in the different regions, special efforts had to be produced to achieve harmonization as described below.

In this paragraph, we describe consecutively:

- the respective methods used by each partner to delineate his own groundwater bodies;
- the procedure to attune the delineations to one another, resulting in the maps of the groundwater bodies in the district in their current form[15] (maps 9 to 11);
- a summary of the main characteristics of the groundwater bodies that results directly from this delineation procedure.

Because the characterization of the recharge zones, as aimed at within the framework of the Scaldit project, is already part of the risk assessment process, we have chosen to process this separately in the next paragraph (§ 3).

2.2 Delineation methods of groundwater bodies

Notwithstanding the fact that the characterization criteria used were quasi common, the different methods used by the partners resulted in a rather clear diversity of delineations for groundwater bodies. We also observed this elsewhere in Europe (e.g. at a workshop of CIS-working group WG 2C on 13 October 2003 in Brussels).

This diversity is mainly characterized by the differences in volume and superposition of the groundwater bodies. This is not only the result of major geological differences at the level of the European basins (the geology of the Dutch plain is clearly distinct from the geology of the Paris Basin or of the Ardennes Massif), but also of different aggregation levels according to the respective objectives concerning groundwater management.

And while, overall, there is little difference in the way in which the major aquifers are delineated, a clear difference can be observed in the choice of delineation for less permeable and less productive aquifers. In this respect, the guidance document for the identification of groundwater bodies defines the concept 'aquifer' on the basis of two criteria: on the one hand, the productivity criterion, and on the other the dependence on surface water ecosystems, whereby, in principle, all non water bearing layers should be removed from the list of groundwater bodies.

In practice, however, the productivity criterion does not specify which extraction conditions the flow refers to, while the criterion concerning the dependence on surface water also remains much too vague. Most of the little permeable layers are therefore automatically associated with neighbouring or underlying aquifers in order not to be ignored.

Some heterogeneous aquifers in loose surface layers, for example, were joined to underlying karst layers or bifurcated aquifers, because their respective productivity was more important than that of the heterogeneous aquifers. In other words: at a given place, at least one groundwater body (the main one) is always assessed, while the vertical section is much more variable.

In the Flemish Region and in the Brussels Capital Region, and to a lesser extent in the Netherlands, the underground is characterized by a regular alternation of moderately thick layers consisting of aquifers, aquitards (little permeable layers) and aquicludes (impermeable layers).

The detailed manner in which each partner delineated the groundwater bodies can be found in the thematic report "Groundwater" of project group P08.

Table 27 gives the main elements.

Table 27 : *Number of groundwater bodies (GWB) and criteria used for their delineation, per region*

	Number of GWB	Vertical section	Hydro-graphical criteria	Hydro-geological criteria	Pressure related criteria	Distinction between free and confined parts
France	16	Normal	Yes	Yes	No	No
Walloon Region	10	Normal	Yes	Yes	Yes	No[16]
BCR	5	Matching the Flemish Region	Not relevant	Yes	No	Yes
Flemish Region	32	Thorough	Yes	Yes	Yes	Yes
Netherlands	4 (+10)[17]	Normal	Not relevant	Yes	No	No

2.3 Harmonisation of the delineation

Notwithstanding the different methods used, after consultation, the partners managed to draft maps of the groundwater bodies in the Scheldt IRBD that match up well at national and regional borders, both horizontally and vertically. Some parts of groundwater bodies have also been added to the Scheldt IRBD or transferred to neighbouring districts when this was required in a hydro-geological context.

The total number of groundwater bodies is 67. If we also add the number of groundwater bodies considered by the Netherlands as groundwater bodies destined for drinking water supply and for industrial purposes, i.e. 10, the total number of groundwater bodies reaches 77.

In the thematic report "Groundwater", the reader will find a table with the list of groundwater bodies, as well as the main characteristics used for the delineation of these groundwater bodies.

2.4 General characteristics of the groundwater bodies

Most partners are currently drawing up detailed descriptive files per groundwater body[18], mentioning not only the hydro-geological characteristics, but also the pressure undergone by these groundwater bodies and the assessment of the risk that the objectives, set by the Directive by 2015, will not be reached. At this stage, we thought it useful to gather the important data in the above common Access-database[19]. You will find the full list of the characteristics that are included in this database in the thematic report "Groundwater".

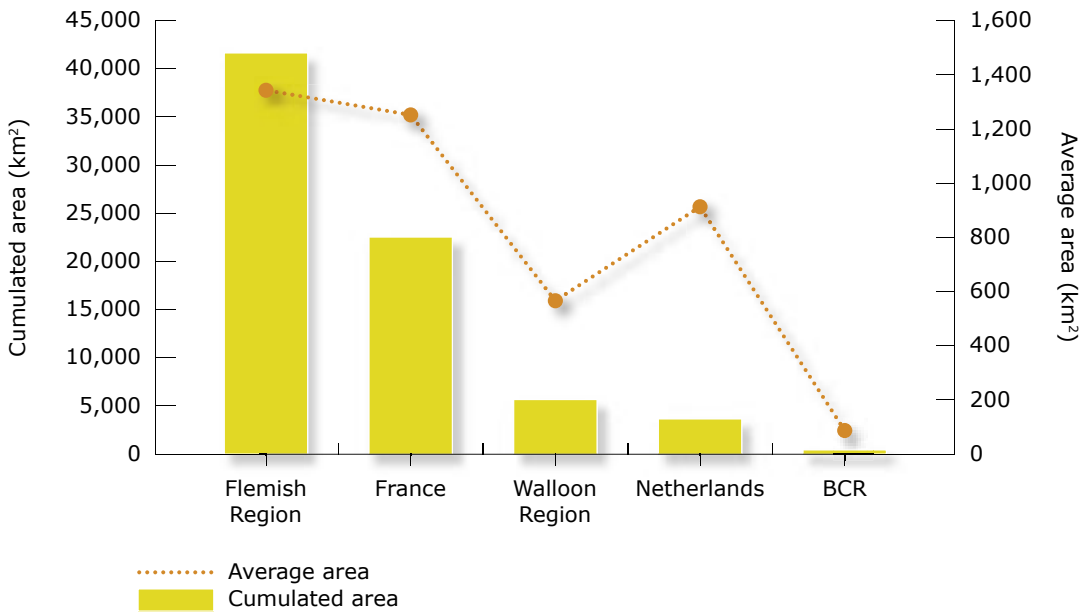
As the pressures, risks and aspects concerning the recharge[20] are described in the following paragraphs, here we only give a short description of the general characteristics of the groundwater bodies at district level.

Regarding the characterization, it is important to know that the Directive gives a very special status to groundwater bodies that cross the borders between different member states (or regions). Such groundwater bodies must be considered as important as any other groundwater body that is initially considered 'at risk'. From the 67 groundwater bodies in the district, 49 or 73% are described as transnational. This means that considerable hydraulic exchanges can take place across borders. Clear criteria and an international coordination at district level are therefore important for groundwater.

However, we must indicate that the relative importance of these transnational groundwater bodies for a given member state or region mainly depends on the area occupied by this state (region) in the district and on the average area of the groundwater bodies as they are delineated. When this is compatible with the flow directions, transnational groundwater bodies are disconnected as much as possible from the 'inland' groundwater bodies in order to avoid useless transnational management for parts of the aquifer that, in all probability, cannot have any impact on or undergo any impact from a neighbouring state (or region).

Regarding the aquifers located on both sides of a boundary between two river basin districts[21], the situation is less harmonious. As these crossings are considered secondary at district level, it was suggested to create one single groundwater body each time by adding the less important parts of the aquifers to the district where the aquifer is dominant. This created a so-called single 'cross-district' groundwater body that is managed in principle by the district where the groundwater body is most important.

Figure 7 : *Comparison between regions of the cumulated area and average area of the groundwater bodies*



However, this rule is not always applied. Some hydrogeological units are divided into two separate water bodies on both sides of the district boundaries.
Thanks to the comparison (see figure 7) of the cumulated area[22] and of the average areas of the groundwater bodies between the different regions, we can form a better idea of the heterogeneity of the delineation of groundwater bodies that was carried out.

At district level, we have 12 groundwater bodies that belong to the Hercynian Basement. By far the most important of these groundwater bodies are those of the **calcareous Carboniferous strata**. These layers form a continuous and highly productive aquifer that is present as a free aquifer in the Walloon Region and, after the border, is mainly confined in France and in the Flemish Region. This aquifer is bifurcated and karsted. In the Walloon Region, this aquifer is divided into two separate groundwater bodies in order to take into account a tendency to overexploit in the most western part, i.e. along the French and Flemish borders.

The other groundwater bodies of the Basement consist of **sandstone-schist strata** that are usually little productive, except along the Brabant Massif (Flemish Region and Walloon Region) where the weathered edges of the Basement can present a higher permeability and are therefore a major source, in particular under the chalk and sand strata.

However, the major part of the groundwater sources in the Scheldt IRBD are produced by **chalky aquifers** (16 groundwater bodies in all, 20 if we also count the mixed aquifer of the Basement and of the chalk strata) which, in proportion, are much larger, especially in France in the form of free aquifers. These chalk layers are bifurcated aquifers that also have a considerable matrix porosity, and are therefore excellent reservoirs. Moreover, karst is also present in some places, increasing the drainage of large amounts of water. Under the tertiary top layer, the chalk strata can be confined or semi-confined (Flemish and Walloon Region), whereby they are better protected against infiltration of pollutants.

The **actual porous aquifers** (gravel, sand, loam) are present in the form of top layers, mainly in the Netherlands and the Flemish Region, less in Northern France and in the Walloon Region. This type of aquifer is the most common (39 groundwater bodies). However, their reserve is highly variable, taking into account their low continuity, limited thickness, and sometimes considerable loam content and, along the coast, penetration of briny seawater. The most productive aquifers are the Brusselian sandy sediments in Belgium. The Netherlands too have a reasonably deep sandy aquifer.

In the Scheldt IRBD, unlike the Meuse IRBD, very few **alluvial aquifers** are present, and only very locally, because of the dominance of clayey sediments in the Scheldt IRBD. This is an important point regarding the exchange between groundwater and surface water. This shows that the main water sources in the district are not found along the Scheldt, but upstream, at the source of the different sub-basins that feed the tributaries. It is therefore mainly in these areas that we will have to examine the effect of the pressures in detail.

3 Characterization of the recharge zones and vulnerability of the groundwater bodies

The Water Framework Directive provides for an assessment of the risk that the groundwater bodies will not achieve the objectives, mainly by taking the pressures into account. In order to assess the impact of existing and future pressures, we must formulate a better definition of vulnerability or, in other words, of the sensitivity of the groundwater bodies to the pressures concerned.

In the Scheldt IRBD, there are 45 groundwater bodies with a free aquifer (of which 12 are confined locally), 21 with a confined aquifer (of which 4 are locally free) and 1 superficial groundwater body.

Via these figures, we can form a first idea of the number of groundwater bodies that have a better natural defence against chemical contamination[23]. But we must remain cautious, because the supply processes of confined layers are generally not well known. While the relationship between one pressure and one quality issue seems obvious in certain cases, in other cases, the absence of any problem cannot be reason enough to exclude the risk.

In any case, the recharge zones play a major part, because they are precisely the strata that take care

Figure 8 : *Principle of vulnerability: the transfer of pressures from the surface towards the aquifers and the ecosystems (adapted according to Foster, 2004)*

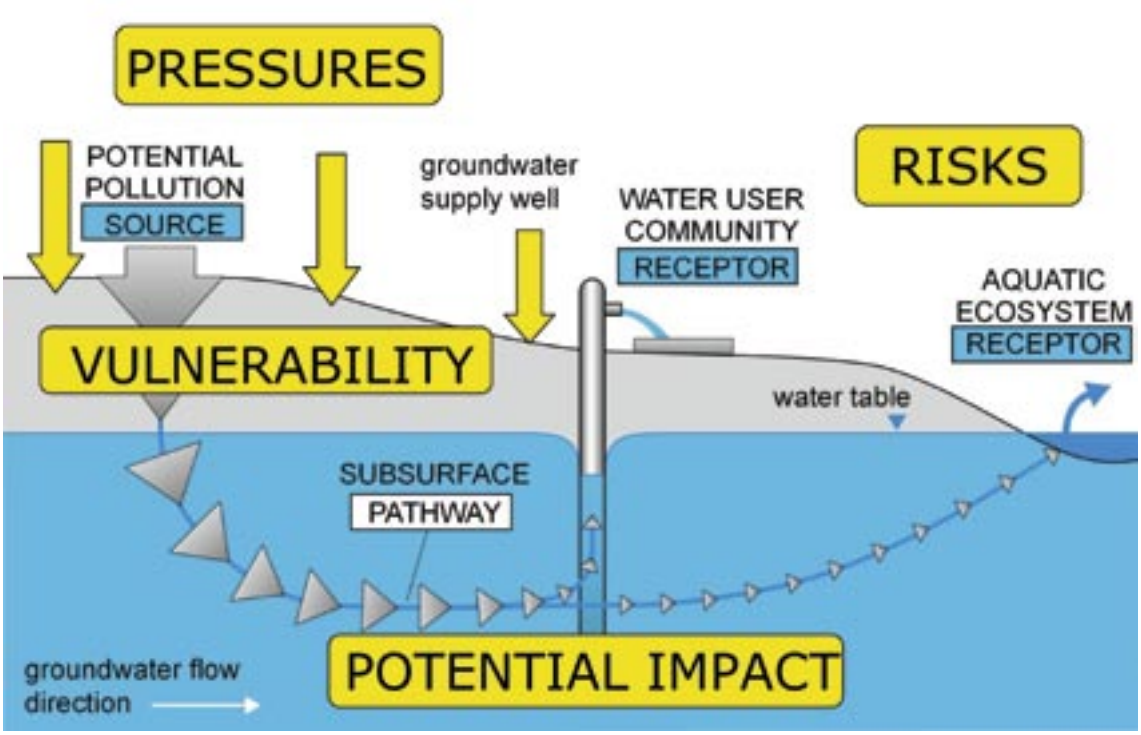
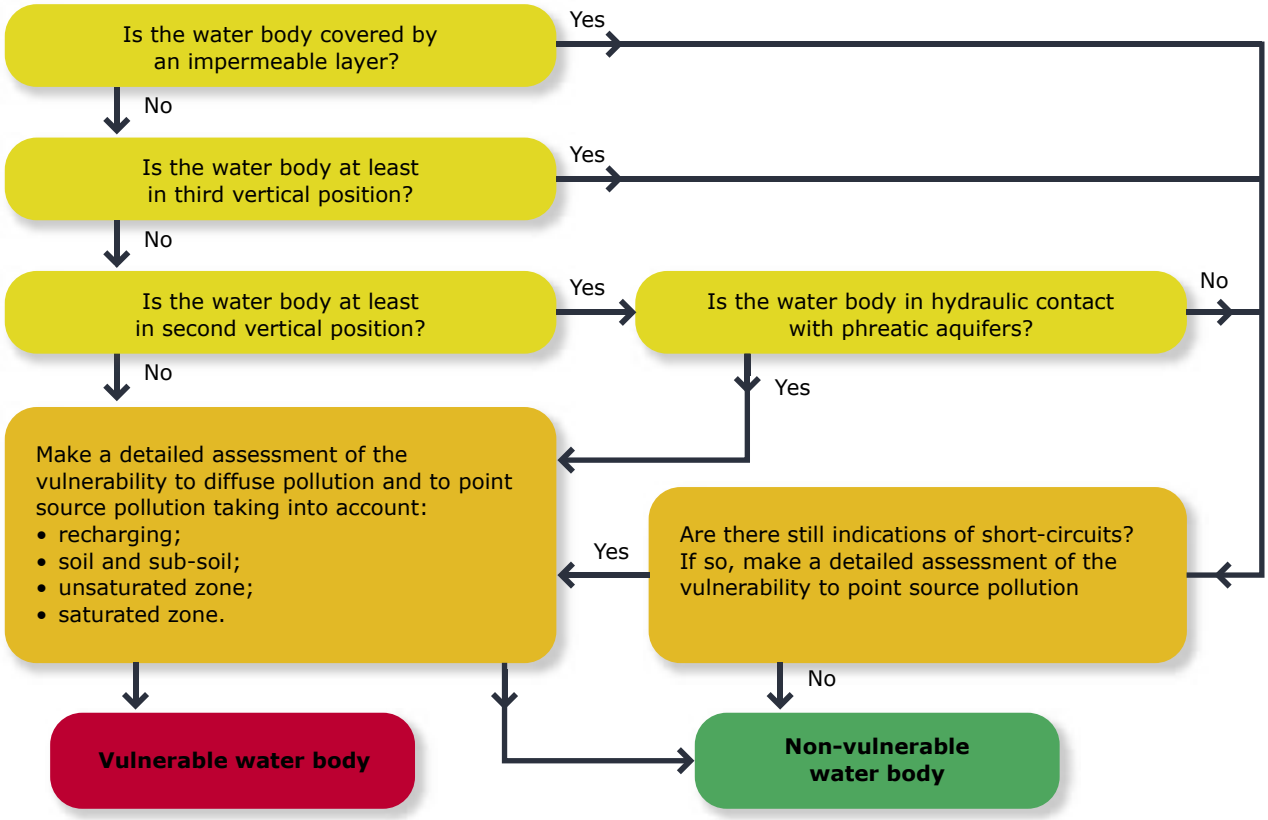


Figure 9 : *Example of a protocol for the assessment of the vulnerability of a groundwater body*



of the transfer or of the potential weakening of the pressures on the groundwater body (see figure 8).

Therefore, we must examine the recharge zones in further detail, especially when the monitoring network in its current configuration doesn't allow us to detect problems.
We must indicate that this is the only useful approach when we must take into account the fact that the resources to be deployed in order to develop a representative monitoring network are excessive.

This aspect of the characterization of groundwater bodies has hardly been discussed by the different partners until recently. Therefore, it was focused on in particular within the framework of the Scaldit project, and this resulted in the development of a specific methodology. This methodology is based on the two following principles:

- determining the most relevant compartments and parameters for the assessment of the vulnerability. Both the parameters and the different indicators were also registered in the Access database (see thematic report "Groundwater");
- determining a protocol with which the vulnerability of groundwater bodies can be assessed in an optimal manner on the basis of available parameters. At this stage, several methods have been proposed or are still being examined. However, no consensus has been reached, because of the large number of data that is required and the duration of scientific developments that would not have been compatible with the deadlines set for completion of a first risk assessment. For information, figure 9 gives an example of the proposed protocol.

Anyway, different types of vulnerability must be determined according to the type of pressure present (diffuse sources or point sources of pollution), because the sensitivity of aquifers also depends on the manner in which pollutants end up in the environment[24]. This aspect is often neglected. Moreover, it is sometimes very difficult to associate a given pressure with a specific way in which pollutants infiltrate the soil.

Table 28 summarizes the provisional results of the vulnerability assessment of groundwater bodies for each region and for the whole district.

Table 28 : *Vulnerability of groundwater bodies with respect to diffuse pollution and point source pollution, per region*

	Vulnera-bility	France (number of GWB)	Walloon Region (number of GWB)	BCR (number of GWB)	Flemish Region (number of GWB)	Nether-lands (number of GWB)	DISTRICT (number of GWB)
Diffuse pollution	high	15	5	0	5	2	27
	moderate	0	2	3	8	1	14
	low	1	3	2	19	1	26
Point source pollution	high	14	4	0	5	2	25
	moderate	1	3	3	8	1	16
	low	1	3	2	19	1	26

Table 29 : *Vulnerability of groundwater bodies with respect to abstractions and artificial recharging, per region*

	Vulnera-bility	France (number of GWB)	Walloon Region (number of GWB)	BCR (number of GWB)	Flemish Region (number of GWB)	Nether-lands (number of GWB)	DISTRICT (number of GWB)
Abstraction	high	0	1	2	6	1	10
	moderate	3	6	2	0	2	13
	low	0	3	0	26	1	30
	unknown	13	0	1	0	0	14
Artificial recharging	high	0	0	0	0	2	2
	moderate	0	0	0	0	1	1
	low	0	10	0	32	1	43
	unknown	16	0	5	0	0	21

We can see that a little over one third of the groundwater bodies are considered as highly vulnerable, and this is less than the number of free or superficial aquifers (46 in all), of which we already said that they do not benefit as good a protection as confined aquifers. The assessments made by the partners are undoubtedly not uniform, and they are probably influenced by the fact that the pressure or pressures of already clearly established impacts have also been taken into account. It is therefore necessary to work out a stricter common approach.

Finally, we noticed that one aspect is lacking almost completely, both in the WFD and in the guidance documents, i.e. the quantitative status. The quantitative objectives are extremely vague. Here, a vulnerability to pressures such as abstractions or even artificial recharging should be investigated, undoubtedly on the basis of a typology (abstraction at the source does not have the same impact as abstraction at a well).

Table 29 gives the provisional results of the vulnerability assessment of groundwater bodies, regarding their quantitative status, for each region and for the complete district.

The large number of groundwater bodies for which no assessment was possible yet indicates clearly the need for a better definition of objectives regarding the quantitative status. This situation also depends on the next point, because the quantitative status of a groundwater body is judged bad when the flow is such that the good qualitative and ecological status of the surface water is threatened.

Table 30 : *Overview of the methods used in each region for the identification of groundwater bodies which surface water ecosystems or corresponding terrestrial ecosystems are dependent on*

	Criteria "Protected areas"		Other criteria to be taken into account	Number of GWB concerned
	Area types	**Number of areas concerned**		
France	Natura 2000*	-	This takes into account a combination of the protected areas and of an analysis on the basis of: • hydro-geological context • hydraulic context • piezometric and flow data	6
Walloon Region	Natura 2000*	-	This takes into account a combination of the protected areas and of an analysis of the hydro-geological context (run-off zones[25])	6
BCR	Natura 2000*	2	This takes into account a combination of the protected areas and of an analysis of the hydro-geological context	1
Flemish Region	Natura 2000*, Ramsar, Nature reserves, VEN**	-	This takes into account a combination of the protected areas and all knowledge about the exchange between groundwater and surface water[26]	18
Netherlands	Natura 2000*	15	Share types of water plants dependent on groundwater	3

*The Natura 2000 areas include the Bird Directive areas and the Habitat Directive areas
**VEN = Vlaams Ecologisch Netwerk (Flemish Ecological Network)

4 Identification of groundwater bodies with dependent surface water ecosystems or groundwater dependent terrestrial ecosystems

No common approach has been developed yet for this issue in the Directive.

The current situation regarding the methods developed by the partners is summarized in table 30. We distinguish two types of methods that are sometimes combined.

The first method takes into account the existence of protected areas. The second method is based on hydro-geological knowledge (exchange between groundwater and surface water) or on ecological criteria. The reader will find further details in the thematic report "Groundwater".

5 Specific pressures on groundwater

The pressures on groundwater that must be taken into account to assess the risks are:
- diffuse sources of pollution;
- point sources of pollution;
- abstraction;
- artificial recharge.

The pressures resulting from the main driving forces are described in chapter IV ("Description of the driving forces and analysis of pressure and impact"). However, some of these pressures must not be examined for groundwater, and no distinction has been made in general between the different ways in which these pressures are exercised on surface water or on groundwater.

The concepts 'point source' and 'diffuse source' of pollution usually refer to the existence or not of a possibility to pinpoint the sources of pollution accurately or even to inventory these sources, and not to the way in which the pollutants penetrate the aquifer (see § 3 of this chapter). This confusion must absolutely be avoided in the method consisting in cross-

analyzing the pressures and the vulnerability in order to deduce the impact.

Another aspect we must take into account is the 'transfer' role played by surface water from the point of view of groundwater pollution. Most pollution cases occur in surface water, and the pollution is then spread to the groundwater. In addition to the major diffuse pressures from agriculture (nitrate and biocides), the pressures of which we assume that they are essential for groundwater are polluted sites (local contamination of the soil and/or of the groundwater).

Certain parameters, such as chlorinated solvents, originate in so-called 'pollution plumes' from polluted sites. The Directive provides for the possibility to define lower environmental objectives for heavily polluted groundwater bodies. However, for groundwater bodies that do not have this specific status, it is useful to take into account the impact of such polluted sites on these groundwater bodies. No consensus has been reached yet on this aspect, because here too, criteria are lacking.

The artificial recharge is of secondary importance at district level. Such activities take place in the Netherlands, where it is estimated that 15% of the water extracted from the dunes and sand strata as drinking water comes from the artificial recharge by surface water, in France, in the Aa valley (department Pas-de-Calais), where surface water infiltrates through the Audomarois chalk layer, as well as in the Flemish Region, where groundwater is recharged artificially on two locations.

Table 31 : *Annual groundwater abstraction quantities, overall and for the drinking water supply, per region*

	Abstracted volume (10^6 m³/jaar)	Abstracted amount for the drinking water supply (10^6 m³/jaar)
France	418	303
Walloon Region	175	137
BCR	3.5	2.5
Flemish Region	218	115
Netherlands	30	24
DISTRICT	844.5	581.5

The most relevant pressures to be taken into account in this chapter are the direct groundwater abstractions, which can have an impact on both the quantitative status and the chemical status of the groundwater bodies.

As the available data are being homogenized still further, the most relevant way to represent these pressures per groundwater body are still being investigated.
However, table 31 summarizes the total amounts of abstracted groundwater per region, as well as the respective quantities that are used for the drinking water supply.

The largest volume of groundwater is abstracted in France (especially in the chalk strata), while in proportion to the area, the abstractions are most intensive in the Walloon Region. Of course, these figures must still be compared with the available water quantity.

Most groundwater by far is abstracted from chalk layers. The karst areas produce as much drinking water as the porous aquifers, even though they are much less frequent in the district.

In the Scheldt IRBD, most of the abstracted groundwater volumes, and in particular the volumes destined for the drinking water supply, are located a priori in a phreatic situation[27], and are therefore highly vulnerable. A better knowledge of the pressures and of the way in which pollutants are transferred is necessary for the risk assessment.

6 Description of the current monitoring networks

The current groundwater monitoring makes it possible to get a better picture of the uncertainties produced by the first assessments of the status of the groundwater bodies and, taking into account the recommendations of the WFD, of the additional monitoring needs.

Tables 32 and 33 summarize the main characteristics of the quantitative and qualitative monitoring networks in each region. A more detailed description of these monitoring networks can be found in the thematic report "Groundwater".

In each region, the quantitative measurements are limited to piezometric observation. Some (France, Walloon Region and Brussels Capital Region) have already made a selection, whereby only those monitoring points are kept that represent the reference status, i.e. those that provide the best representation of the status on the scale of the groundwater body.

At this stage, the other regions (Flemish Region and Netherlands) chose to keep the multiplicity of the available monitoring points within different types of monitoring networks, whether they reflect the reference status or, on the contrary, are precisely aimed at monitoring specific problems. This clearly highlights the current lack of criteria to establish a monitoring network on the scale of a groundwater body, as well as the necessity to work with highly attuned monitoring networks.

As for the qualitative monitoring networks, the average density of the monitoring points varies between 1 and 20 (± 5 if the observation above is taken into account) per 100 km². Eurowaternet recommends a density of 1 station per 100 km² in normal conditions and 4 stations per 100 km² in areas subjected to heavy pressures. Some monitoring networks will undoubtedly need to be changed from the point of view of spatial distribution.

We also notice that, in some cases (France, Walloon Region), the measurements are currently almost exclusively limited to abstractions, while in other cases (Flemish Region) monitoring points linked with quality issues can already be included.

Just like for the quantitative monitoring networks, this rises the problem of representativeness of the monitoring networks. To what extent do we need to include monitoring points that are subjected to heavy pressures locally or, on the contrary, monitoring points that are exceptionally well protected?

Table 32 : *Summary of the main characteristics of the quantitative monitoring networks per region*

	Type of monitoring network	**Type of measurement**	**Number of selected monitoring points (number with automatic registration)**	**Average density of the monitoring points (per 100 km² GWB)**	**Representativeness according to the WFD**
France	Reference	Piezometric	182	1	Insufficient for three GWB
Walloon Region	Reference	Piezometric	240 (29)	4	Insufficient
BCR	Reference	Piezometric	25	6	Insufficient
Flemish Region	Primary monitoring network on three levels: • reference • specific • local	Piezometric	300	2.5[28]	Insufficient
Netherlands	On three levels: • regional • local • macro	Piezometric	Total number ± 458 (including not active) • active: 92 • active: 76 • active: 48	22	Insufficient

Table 33 : *Summary of the main characteristics of the qualitative monitoring networks per region*

	Type of monitoring network	**Type of measurement**	**Monitoring frequency (per year)**	**Number of selected monitoring points (number with automatic registration)**	**Average density of the monitoring points (per 100 km² GWB)**	**Representativeness according to WFD**
France	Abstractions and springs	Physico-chemical, mineral macro-pollutants and micro-pollutants	2	190	1	Insufficient for three GWB
Walloon Region	Abstractions and nitrate monitoring points	All drinking water parameters (Dir. 80/778/EEC)	1 (mineral composition) up to 12 (pesticides)	150 + 50	3	Insufficient
BCR	Reference	All drinking water parameters	2	7	2	Insufficient
Flemish Region	Primary monitoring network on three levels: • reference • specific • local MAP monitoring network for nitrates	All parameters on a selection of 300 monitoring points and nitrates on 2104 monitoring points	Primary monitoring network: 12 MAP monitoring network: 4 (priority wells) or 2 (other wells)	300 + 2,104	20[29]	Sufficient
Netherlands	National and provin-cial	pH, conductivity, temperature (lab and in situ), Na, K, Ca, Mg, NH_4^+, Fe, Mn, Al, Cl, SO_4^{2-}, HCO_3^-, NO_3^-, PO_4^{3-}, P_{tot}, $N_{Kjeldahl}$, Cr, Cu, Pb, Ni, Zn, As, Cd	1	68	3-4	Insufficient