Common Implementation Strategy 
for the Water Framework Directive (2000/60/EC)

Groundwater summary report

Technical report on groundwater body characterisation, monitoring and risk assessment issues as discussed at the WG C workshops in 2003–2004

December 2005
Foreword

The EU Member States, Norway and the European Commission have jointly developed a common strategy for supporting the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (hereafter referred to as Common Implementation Strategy (CIS) for the Water Framework Directive (WFD)). The main aim of this strategy is to allow a coherent and harmonious implementation of this Directive. Focus is on methodological questions related to a common understanding of the technical and scientific implications of the Water Framework Directive.

In this framework, a working group on Groundwater Body Characterisation and Monitoring has been established, with the aim – during the period 2003–2004 – to exchange information/experience on groundwater issues covered by the WFD (e.g. body characterisation, risk assessment, monitoring, chemical status and trends) in the form of workshops and technical reports gathering the participant’s experience.

For each of the workshops on groundwater body characterisation, monitoring and risk assessment a workshop report was elaborated summarizing the groundwater related aspects already covered by the CIS guidance documents which were developed within the first phase of the CIS and supplemented by experiences gained so far within the implementation process and examples of practices presented at the national, regional or Pilot River Basin levels.

This summary report summarises most important aspects covered by the workshop reports.
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1 Introduction

1.1 The Common Implementation Strategy (CIS) of the WFD

The Water Framework Directive (2000/60/EC)\(^1\) is a comprehensive piece of legislation that sets out, *inter alia*, “good status” objectives for all waters in Europe. The Directive provides for a sustainable and integrated management of river basins including binding objectives, clear deadlines and comprehensive programme of measures based on scientific, technical and economic analysis including public information and consultation. Soon after the WFD adoption, it has become clear that the successful implementation of the Directive will be equally as challenging and ambitious for all countries, institutions and stakeholders involved. Therefore, a strategic document establishing a Common Implementation Strategy (CIS) for the Water Framework Directive (WFD) was developed and finally agreed under the Swedish Presidency in the meeting held in Sweden on 2–4 May 2001. Despite the fact that it was recognised that implementing the WFD is the full responsibility of the individual Member State, there was a broad consensus amongst the Water Directors of the Member States, Norway and the Commission that the European joint partnership was necessary in order to:

- develop a common understanding and approaches;
- elaborate informal technical guidance including best practice examples;
- share experiences and resources;
- avoid duplication of efforts; and
- limit the risk of bad application.

Furthermore, the Water Directors stressed the necessity to involve stakeholders, NGOs and the research community in this joint process as well as to enable the participation of Candidate Countries in order to facilitate their cohesion process. Following the decision of the Water Directors, a comprehensive and ambitious work programme was started of which the first phase, including ten Working Groups and three Expert Advisory Fora, was completed at the end of 2003\(^2\) and led to the availability of fourteen Guidance Documents which are publicly available\(^3\). These documents were tested in Pilot River Basins across Europe in 2003 and 2004.

In the new Work Programme 2005/2006, the four Working Groups (WG A - Ecological Status, WG B - Integrated River Basin Management, WG C - Groundwater and WG D - Reporting) have continued addressing the key issues for implementation. In addition, ad-hoc expert groups on ‘WFD and Agriculture’, ‘GIS’ and ‘Chemical Monitoring’ are sharing experiences in this area and a new Pilot River Basin network is supporting the technical activities in all working groups.

1.2 Working Group C - Groundwater

The CIS Working Group on Groundwater (WG C) has been established to exchange information/experience on groundwater issues covered by the WFD (e.g. body characterisation, risk assessment, monitoring, chemical status and trends) in the form of workshops and technical reports gathering the participant’s experience.

In the 2003-2004 work programme, four workshops of WG C focused on groundwater body characterisation, monitoring, risk assessment and on status and trends, gathering more than 80 participants from both the WG C and the WG B. The aim of the workshop was to share national and regional experiences, taking into account the CIS guidance.

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For each of the workshops on body characterisation, monitoring and risk assessment a workshop report was elaborated summarizing the groundwater related aspects already covered by the CIS guidance documents which were developed within the first phase of the CIS and supplemented by experiences gained so far within the implementation process and examples of practices presented at the national, regional or Pilot River Basin levels. The present groundwater summary report provides key elements of groundwater body characterisation, monitoring and risk assessment.

The 2005-2006 WG C work programme is now focusing on drafting a technical guidance document covering salient groundwater features from the WFD and the new groundwater directive.

1.3 Groundwater Directive


Based on an EU-wide approach, the proposed Directive introduces, for the first time, quality objectives, obliging Member States to monitor (in accordance with existing requirements under the Water Framework Directive, see below) and assess groundwater quality on the basis of common criteria and to identify and reverse trends in groundwater pollution. By adopting the proposal, the Commission has fulfilled an obligation under the Water Framework Directive. Due to the need to set out detailed provisions regarding groundwater chemical status and pollution trends, it asked for groundwater protection to be tackled separately in a Daughter Directive.

The proposed Directive will ensure that groundwater quality is monitored and evaluated across Europe in a harmonised way, at the same time leaving a considerable degree of flexibility to the Member States on how to achieve the environmental objectives.

The European Parliament adopted its first-reading opinion on 28th April 2005. A political agreement has been reached at Council on 24th June 2005 and the Common Position has been adopted on 8th December. The second reading is expected to be completed before June 2006.

In the period between the adoption of the proposal and the adoption of the future Groundwater Directive by the European Parliament and the Council, it has been decided to organise regular workshops to exchange information and experiences among WG C.

2 Water Framework Directive

In simple terms the Water Framework Directive (also known as the WFD or Directive 2000/60/EC) is a legislative framework to protect and improve the quality of all water resources within the European Union such as rivers, lakes, groundwater, transitional and coastal water up to one sea mile (and for the chemical status also territorial waters which may extend up to 12 sea miles) from the territorial baseline of a Member State, independent of the size and the characteristics. The WFD was published and entered into force in December 2000. Member States had to incorporate the WFD into national law by the end of 2003. Thereafter, many more steps must be taken to achieve ‘good status’ of all European waters by 2015.

The totality of waters is, for the purpose of the implementation of the Directive, attributed to geographical or administrative units, in particular the ‘river basin’, the ‘river basin district’, and the ‘water body’. Relevant definitions are provided under Article 2 of the Directive.

- ‘River basin’ means the area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta.
- ‘Sub-basin’ means the area of land from which all surface run-off flows through a series of streams, rivers and, possibly, lakes to a particular point in a water course (normally a lake or a river confluence).
‘River basin district’ means the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters, which is identified under Article 3(1) as the main management unit for river basins.

‘Good groundwater status’ means the status achieved by a groundwater body when both its quantitative status and its chemical status are at least ‘good’.

With regard to groundwater, ‘groundwater bodies’ are the units that will be used for reporting and assessing compliance with the Directive’s principal environmental objectives.

### 2.1 Objectives

The objectives of the WFD are laid down in Article 4. For groundwaters the following objectives are essential:

1. To implement measures to prevent or limit the input of pollutants into groundwater and to prevent the deterioration of the status of the groundwater body (groundwater status consists of two parts; quantitative status and chemical status and the overall status of groundwater is taken to be the poorer of the two);

2. To protect, enhance and restore all bodies of groundwater, and ensure a balance between abstraction and recharge of groundwater, with the aim of achieving good groundwater status by 2015 in accordance with the provisions laid down in Annex V;

3. To reverse any significant and sustained upward trend in the concentration of any pollutant resulting from the impact of human activity in order to progressively reduce pollution of groundwater.

‘Good groundwater chemical status’ is the chemical status of a body of groundwater, which meets all the conditions set out in table 2.3.2 of Annex V. Hence, the chemical composition of the groundwater body is such that

- the concentrations of pollutants do not exhibit the effects of saline or other intrusions,
- do not exceed the quality standards applicable under other relevant Community legislation and
- 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.

‘Good quantitative status’ is the status defined in table 2.1.2 of Annex V.

- The level of groundwater is such that the available groundwater resource 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 and any significant damage to terrestrial ecosystems which depend directly on the groundwater body.
- 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.

It is required that objectives for protected areas established under Community legislation should also be met. For example, if a water body falls within a Nitrate Vulnerable Zone then the objectives of the Nitrates Directive (91/676/EEC) must be met. Article 7 of WFD requires Member States to establish protected areas for all bodies of water providing more than 10 m³ drinking water a day as an average or serving more than 50 persons, or bodies intended for that use in the future. The objective for these areas is to avoid deterioration in quality in order to reduce the level of purification treatment required.
2.2 Time Table

The WFD requires the achievement of its principal objectives, good groundwater status, by the end of 2015 at the latest.

To reach these objectives each Member State had to undertake for each river basin district or for the portion of an international river basin district falling within its territory (Article 5) an analysis of its characteristics, a review of the impact of human activity on the status of surface waters and on groundwater, and an economic analysis of water use according to the technical specifications set out in Annexes II and III at the latest in 2004. These analyses and reviews have to be reviewed, and if necessary updated at the latest in 2013 and every six years thereafter.

Article 15 specifies the reporting requirements of the review undertaken under Article 5. Member States were required to provide summary reports of the reviews within three months of their completion (i.e. by March 2005 at the latest for the first review). Subsequently, reporting on these reviews will be contained in the River Basin Management Plans (RBMPs), which must be published first in 2009, and thereafter every six years (2015, 2021...). Therefore, from 2009 a schedule with a six-year cycle shall be established, with the review of pressures and impacts occurring two years prior to the publishing of the RBMP.

The review of the pressures and impacts is required for the design of monitoring programmes which must be operational by 2006 (Article 8), and also to help develop programmes of measures which must be established by 2009, and made operational by 2012 (Article 11).

The Water Framework Directive establishes a planning framework to, among other things, support the achievement of the standards and objectives for Protected Areas established under Community legislation. In the context of groundwater, these areas may include Natura 2000 sites established under the Habitats Directive (92/43/EEC) or the Birds Directive (79/409/EEC), Nitrate Vulnerable Zones established under the Nitrates Directive (91/676/EEC) and Drinking Water Protected Areas established under Article 7 of the Water Framework Directive. The register of protected areas had to be established by March 2005.

Table 1: Actions and dates by which they must be achieved (note that in practice many actions must be completed within a fixed period of the completion of a prerequisite task).

<table>
<thead>
<tr>
<th>Action</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact review completed by Member States (Article 5, Article 15, Annex II)</td>
<td>2004</td>
</tr>
<tr>
<td>Register of protected areas established (Article 6)</td>
<td>2004</td>
</tr>
<tr>
<td>Summary reporting of impact review to Commission (Article 15)</td>
<td>2005</td>
</tr>
<tr>
<td>Monitoring programme operational (Article 8)</td>
<td>2006</td>
</tr>
<tr>
<td>Interim overview of the significant water management issues (Article 14.1b)</td>
<td>2007</td>
</tr>
<tr>
<td>Draft river basin management plan for public consultation (Article 14.1c)</td>
<td>2008</td>
</tr>
<tr>
<td>Publication of the first River Basin Management Plan (Article 15)</td>
<td>2009</td>
</tr>
<tr>
<td>Programme of measures established (Article 11)</td>
<td>2009</td>
</tr>
<tr>
<td>Programme of measures operational (Article 11)</td>
<td>2012</td>
</tr>
</tbody>
</table>
3 Groundwater body identification

A groundwater body should be a coherent sub-unit in the river basin (district) to which the environmental objectives of the Directive must apply. Hence, the main purpose of identifying these bodies is to enable the (quantitative and chemical) status to be accurately described and compared to environmental objectives.

The application of the term ‘body of groundwater’ must be understood in the context of the hierarchy of relevant definitions provided under Article 2 of the Directive.

- ‘Groundwater’ means all water, which is below the surface of the ground in the saturated zone and in direct contact with the ground or subsoil.
- ‘Aquifer’ means a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater.
- ‘Body of groundwater’ means a distinct volume of groundwater within an aquifer or aquifers.

As a consequence of the above listed hierarchy of definitions, the suggested first step in the identification of bodies of groundwater requires a general interpretation of the term aquifer, in respect what constitutes a ‘significant flow’ of groundwater and what volume of abstraction would qualify as a ‘significant quantity’.

A ‘significant flow’ of groundwater is one that, were it from reaching an associated surface water body or a directly dependant terrestrial ecosystem, would result in a significant diminution in the ecological or chemical quality of that surface water body or significant damage to the directly dependent terrestrial ecosystems. Article 7 of the WFD requires the identification of all groundwater bodies used, or intended to be used, for the abstraction of more than 10 m³ of drinking water a day as an average. By implication, this volume could be regarded as a ‘significant quantity’ of groundwater.

3.1 Delineation of groundwater bodies

The identification and delineation of groundwater bodies is based on geographical and hydrological determinants. The Directive’s definition of aquifer requires two criteria to be considered in determining whether geological strata qualify as aquifers (Figure 1). If either of the criteria is met, the strata will constitute an aquifer or aquifers. In practice, the criteria mean that nearly all groundwater in the Community would be expected to be within aquifers.

![Figure 1: The Directive’s definition of aquifers](image-url)
The identification of groundwater bodies must be consistent and co-ordinated within a river basin district. In particular, international river basin districts need to develop common approaches for the whole river basin.

Most countries started with the identification of geological and hydrogeological boundaries but applied a comprehensive set of further criteria like vulnerability maps, subsoil properties, risk potential, utilisation and protection need, economic importance and water management aspects.

Groundwater bodies should be delineated in three dimensions. The depth of groundwater within an aquifer or aquifers should depend on the risks to fail the Directive’s objectives.

Although most pressures will affect the relatively shallow component of a groundwater flow, groundwater flow at depth can still be important to surface ecosystems - even though this may be over an extended timescale. The WFD definitions of aquifer and body of groundwater permit groundwater bodies to be identified either (a) separately within different strata overlaying each other in the vertical plane, or (b) as a single body of groundwater spanning the different strata. This flexibility enables Member States to adopt the most effective means of achieving the Directive’s objectives given the characteristics of their aquifers and the pressures to which they are subject. For example, where there are major differences in status of the groundwater in strata at different depths, it may be appropriate to identify different bodies of groundwater (i.e. one on top of another) to ensure the status of groundwater can be accurately described, and the Directive’s objectives appropriately targeted. However, it is important to be noted that all groundwater is subject to the ‘prevent or limit’ objective (Article 4.1 of WFD) whether or not it is identified as being part of a body of groundwater.

Major changes in the status of groundwater should be taken into account when delineating groundwater body boundaries to ensure that, as far as practical, water bodies provide for an accurate description of groundwater status. Where status is consistent, large bodies of groundwater may be delineated. Where status differences are reduced during a planning cycle, Member States may recombine subdivisions of groundwater of the same status for the purposes of subsequent planning cycles. However, water bodies must at least be fixed for each plan period.

The degree of subdivision of groundwater into bodies of groundwater is a matter for Members States to decide on the basis of the particular characteristics of their river basin districts. In making such decisions, it will be necessary for Member States to balance the requirement to adequately describe groundwater status with the need to avoid the fragmentation of aquifers into unmanageable numbers of water bodies.

The identification of groundwater bodies should be an iterative and on-going process. Figure 2 suggests the hierarchical process for identifying bodies of groundwater based on the principles described.
In the Member States the delineation process was mainly based on previous surveys, already existing delineations, maps and studies. In several countries (e.g. Austria, Denmark, Germany, Hungary, the Netherlands, Portugal, Sweden) the delineation predominantly started with the identification of geological boundaries, followed by hydrogeological features and topography and took into account actual and potential utilisation, protection needs, risk potential, economic importance and water management aspects such as already existing water management units, administrative borders or the borders of the river basin districts. The most important aim of the countries was to achieve efficient and practical inventory and management units and to keep the administrative burden and the financial efforts within practicable dimensions.

3.2 Grouping of groundwater bodies

Groundwater bodies may be grouped for the purposes of the risk assessment. Groundwater bodies may also be grouped for monitoring, reporting and management purposes where monitoring of sufficient indicative or representative water bodies in the sub-groups of groundwater bodies provides for an acceptable level of confidence and precision in the results of monitoring, and in particular the classification of water body status.

Grouping of groundwater bodies could also contribute to a most cost effective pressures and impacts analyses. The ability to group bodies will depend on the characteristics of the river basin district and the type and extent of pressures on it. However, such grouping must be undertaken on a scientific basis so that monitoring information obtained for the group provides for a suitably reliable assessment that is valid for each body in the group and for an acceptable level of confidence and precision in the results of monitoring.

Especially the Nordic countries Finland and Norway are confronted with a huge number of groundwater bodies due to the specific geological characteristics. Finland identified about 3700 groundwater bodies according to the WFD which will be grouped in order to reduce administrative burdens. In Norway the grouping of individual aquifers (8000–11000) into less than 1000 groundwater bodies is based on the analogous principle (both quantitatively and qualitatively), and on the aim to reduce the number of groundwater bodies to a more realistic level for effective and economic management.
3.3 Timetable and refinement for the identification of water bodies

The WFD requires Member States to identify groundwater bodies as part of the analysis of the characteristics of the river basin districts (Article 5). The first such analysis had to be complete by 22 December 2004. The analysis must be reviewed, and where necessary, the water body identification should be verified and refined in the period before the publication of each river basin management plan by 22 December 2013 and then every six years.

However, identifying groundwater bodies that will provide for an accurate description of the status require information from the Article 5 analyses and reviews and the Article 8 monitoring programmes. Some of the necessary information was not available before 2004. The information that was available is likely to be updated and improved in the period prior to the publication of each river basin management plan. Therefore, verification and refinement steps of groundwater body identification should be foreseen in the implementation process.

4 Groundwater body characterisation

Article 5 of the WFD requires that the characteristics of the river basin districts has to be analysed and a review of the environmental impact of human activity, as well as an economic analysis of water use, has to be undertaken.

A specification for the impact review for groundwater is contained in WFD Annex II 2 and includes five parts (see Figure 3):

- Initial characterisation, including identification of pressures and risk of failing to achieve objectives;
- Further characterisation of groundwater bodies identified as being at risk;
- Review of the impact of changes in groundwater levels for groundwater bodies for which lower objectives are to be set according to Article 4.5;
- Review of the impact of human activity on groundwaters for transboundary and at risk groundwater bodies; and
- Review of the impact of pollution on groundwater quality for which lower objectives are to be set.

The most important goal of this first review is to understand the significant water management issues within each river basin and how they affect each individual water body. The timetable for completing the first pressures and impacts analyses and reporting their results was very short. The first analyses therefore relied heavily on existing information on pressures and impacts and existing assessment methods.
4.1 Initial characterisation

The initial characterisation of all groundwater bodies (Annex II 2.1) comprises to assess their uses and the degree to which they are at risk of failing to meet the objectives of Article 4 of the WFD, namely the achievement of good (quantitative and chemical) status of groundwater at the latest by the end of the year 2015.

Based on the delineation of groundwater bodies pressures to which the groundwater bodies are liable to be subject to shall be identified (including diffuse and point sources of pollution, abstraction, and artificial recharge). In addition, the general character of the overlying strata in the catchment from which the groundwater body receives its recharge shall be described, as well as the groundwater bodies for which there are directly dependent surface water ecosystems or terrestrial ecosystems.

The initial characterisation requires a general analysis of pressures corresponding to that described above, but set in the context of evaluating the risk of failing to meet the objectives. This requires an understanding of the nature of the impact that may result from a pressure, and appropriate methods to monitor or assess the relationship between impact and pressure.

Chapter 5 provides details on the identification of human activities and groundwater risk assessment.

4.2 Further characterisation

Following the initial characterisation, a further characterisation has to be carried out for those groundwater bodies or groups of bodies which have been identified as being at risk in order to establish a more precise assessment of the significance of such risk and identify any measures to be required under Article 11 of the WFD. The approach recommended follows that outlined for initial characterisation, but requires the collection of more detailed information and data, such as that detailed in Annex II 2.3, e.g. geological and hydrogeological characteristics, the characteristics of the superficial deposits and soils, an inventory of associated surface systems, estimates of the flow directions etc.

The wording of Annex II suggests that the information specified shall be included ‘where relevant’. In this context ‘relevant’ is taken to mean relevant to the assessment of risk of failure to meet Article 4 objectives. It does not give licence to avoid collecting information. The concept of ‘relevance’ also
involves questions of the level of detail that should be sought and, for human activities, the timescale over which the effects of the activity may be deemed relevant. In deciding these matters it is important to refer back to the purpose of further characterisation - to improve the assessment of risk and identify any measures to be required under Article 11.

4.3 Transboundary groundwater bodies
Specific provisions concern those bodies of groundwater which cross the boundary between two or more Member States, focusing mainly on quantitative aspects such as the location of groundwater abstraction points serving more than 10 m³ a day or more than 50 persons, the abstraction rates, direct discharges to groundwater etc. However, the way to deal with transboundary groundwater bodies is not yet clarified and should be further developed (some PRB used national borders to separate water bodies while others defined transboundary bodies).

4.4 Lower objectives
Connected to the further characterisation, the WFD also requires as a review of impacts of changes in groundwater levels the identification of those bodies of groundwater for which lower objectives are to be specified under Article 4 including as a result of consideration of the effects of the status of the body on (Annex II 2.4): 1. Surface water and associated terrestrial ecosystems; 2. Water regulation, flood protection and land drainage, and 3. Human development.

Finally, Member States have to identify those bodies of groundwater for which lower objectives are to be specified under Article 4(5) of the WFD where, as a result of the impact of human activity, and as determined in accordance with the analysis of pressures and impacts, the body of groundwater is so polluted that achieving good groundwater chemical status is infeasible or disproportionately expensive (Annex II 2.5).

4.5 Interaction with aquatic and terrestrial ecosystems
Important aspects to be considered for the characterisation of groundwater bodies are the interactions with associated surface waters and terrestrial ecosystems. Indeed, the definition of good groundwater chemical status implies that the concentrations of pollutants in a defined groundwater body should not result in failure to achieve the environmental objectives under Article 4 of the WFD 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.

4.6 Timetable
The first analyses and review was due in 22 December 2004 and had to be reported by Member States in March 2005. These analyses have to be reviewed, and if necessary updated at the latest in 2013 and every six years thereafter.

5 Groundwater risk assessment
The groundwater risk assessment is part of the characterisation and the review of the environmental impacts of human activity already introduced in Chapter 4. For each groundwater body the degree to which it is at risk of failing to meet the objectives under Article 4 has to be assessed.

A common understanding of terms and the most effective approach for groundwater risk assessment was developed within the IMPRESS working group. The widely-used Driver, Pressure, State, Impact, Response (DPSIR) analytical framework had been adopted with definitions as in Table 2.
Table 2: The DPSIR framework as used in the pressures and impacts analysis

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver</td>
<td>An anthropogenic activity that may have an environmental effect (e.g. agriculture, industry)</td>
</tr>
<tr>
<td>Pressure</td>
<td>The direct effect of the driver (for example, an effect that causes a change in flow or a change in the water chemistry)</td>
</tr>
<tr>
<td>State</td>
<td>The condition of the water body resulting from both natural and anthropogenic factors (i.e. physical and chemical characteristics)</td>
</tr>
<tr>
<td>Impact</td>
<td>The environmental effect of the pressure (e.g. ecosystem modified)</td>
</tr>
<tr>
<td>Response</td>
<td>The measures taken to improve the state of the water body (e.g. restricting abstraction, limiting point source discharges, developing best practice guidance for agriculture)</td>
</tr>
</tbody>
</table>

It is worth noting in the context of the DPSIR framework as described above, that objectives defined by the WFD relate to both the state and the impact, since, standards from other European water quality objective legislation relate to the concentration of pollutants in the water body (i.e. its state), while the biological elements of the WFD clearly indicate impacts.

5.1 Procedure

Ideally, a pressures and impacts assessment will be a four-step process.

4. Identifying the driving forces (especially land use, urban development, industry, agriculture and other activities which lead to pressures) without regard to their actual impacts and identifying pressures with possible impacts on the water body and on water uses;

5. Identifying the significant pressures, by considering the magnitude of the pressures and the susceptibility of the water body;

6. Assessing the impacts resulting from the pressure; and,

7. Evaluating the likelihood of failing to meet the objective.

Figure 4: Key components in the analysis of pressures and impacts.
To undertake the four key stages, three supporting elements must be considered (shown on the left of Figure 4). The description of a water body and its catchment area will underpin the pressures and impacts analysis. During the process, monitoring data relevant to the water body may also be introduced. A comparison of monitoring data with driving forces may help to screen where pressures are likely to cause a failure in meeting objectives. It is also necessary to understand the objectives against which the actual state will be compared (see Chapter 2.1). In many cases these key stages need not be undertaken as a linear sequence but in general, all key stages are to be addressed.

5.2 Conceptual model/understanding

Assessing the impacts on a water body requires some quantitative information to describe the state of the water body itself and/or the pressures acting on it. The type of analysis will be dependent on what data are available. Regardless of the particular process to be adopted, and as with the identification of significant pressures described above, the assessment requires a conceptual understanding of what causes impacts.

Conceptual models/understandings are simplified representations, or working descriptions, of the hydrogeological system being investigated. Their development underpins much of the work carried out as part of the characterisation process. As the amount of, and confidence in, the available environmental information increases, the accuracy and complexity of the model improves, so that they become more effective and reliable descriptions of the system.

A conceptual model/understanding is furthermore necessary to design monitoring programmes and it is necessary to interpret the data provided by those programmes, and hence assess the achievement of the Directive’s objectives. The testing of conceptual models/understandings is important to ensure they provide for acceptable levels of confidence in the assessments they enable. A successful pressures and impacts study will not be one that follows prescriptive guidance. It will be a study in which there is a proper understanding of the objectives, a good description of the water body and its catchment area (including monitoring data), and a knowledge of how the catchment-system functions (Figure 5).

![Conceptual schemes of groundwater pollution risk assessment](image)

**Figure 5: Conceptual schemes of groundwater pollution risk assessment**

A conceptual understanding/model is dynamic, evolving with time as new data are obtained and as the model is tested. Its development and refinement should adopt an iterative approach (see Figure 6). The approach therefore fits in well with the various levels of knowledge required at different stages of the WFD. For example a basic model will be appropriate for initial characterisation; this (if appropriate) will be refined and improved during further characterisation, and again during the review cycle of the RBMP. The construction of basic conceptual models of groundwater flow and
chemical systems, and then of groundwater bodies should be undertaken early in the process of initial groundwater characterisation. This will include the delineation of the groundwater body boundaries and an initial understanding of the nature of the flow and geochemical system and interaction with surface water bodies and terrestrial ecosystems. It will also involve water quality information and an early assessment of pressures. In essence the model should describe the nature of the aquifer system, both in terms of quantity and quality, the likely consequences of pressures and the potential effects of human activities on it. It should be proportionate in terms of its detail and complexity to the likely risks to the objectives for that body, or group of bodies.

**Definition of conceptual modelling/ understanding**
A conceptual model/understanding is a simplified representation, or working description, of how the real hydrogeological system is believed to behave. It describes how hydrogeologists believe a groundwater system behaves.

- It is a set of working hypotheses and assumptions
- It concentrates on features of the system that are relevant in relation to the predictions or assessments required
- It is based on evidence
- It is an approximation of reality
- It should be written down so that it can be tested using existing and/or new data.
- The level of refinement needed in a model is proportionate to (i) the difficulty in making the assessments or predictions required, and (ii) the potential consequences of errors in those assessments.

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**Figure 6: Definition of conceptual modelling/ understanding**

5.3 Identification of driving forces and pressures
Driving forces are sectors of activities that may produce a series of pressures. A pressure results from an activity that may directly cause deterioration in the status of a water body. In most cases, a pollution pressure relates to the addition, or release, of substances into the environment. This can be the discharge of a waste product, but may also be the side-effect or by-product of some other activity, such as the leaching of nutrients from agricultural land. A pollution pressure may also be caused by an action such as a change in land use.

The most usual categorisation of pollution pressures is to distinguish between diffuse and point sources. However, the distinction between point and diffuse sources is not always clear, and may
again relate to spatial scale. For example, areas of contaminated land might be considered as either diffuse or point sources of pollution. A quantitative pressure relates to the change of groundwater levels or the modification of flow directions but also to the intrusion of salinity, the reduced dilution of chemical fluxes or the modification of dependent aquatic or terrestrial ecosystems. This can be changes in land use like land sealing, water abstraction or artificial recharge.

The pressures and impacts analyses should be focused in such a way that the effort involved in assessing whether any body, or group of bodies, is at risk of failing to achieve its environmental objectives is proportionate to the difficulties involved in making that judgement. A screening approach is likely to simplify the tasks prior to additional description and analysis at a later stage, as it means focusing on the search for pressures on those areas and pressure types that are likely to prevent meeting the objectives and pointing out with simple assessments those water bodies that are clearly ‘at risk’ or not at risk in failing to achieve good status in 2015. The screening approach may be carried out in any order (assess state, assess lack or certainty of impact), using driving force assessment as substitute of pressures. Driving forces are quantified by aggregated data, simple to obtain, e.g.: hectares of arable land, population density, etc., per area. Comparing this driving force data with appropriate aggregated monitoring information quickly allows assessing the likelihood that the considered driving force is related to environmental pressures. In that case, only the expected pressures should be investigated in greater details.

The screening procedure is not only a way to speed up data collection by focusing on those pressures that are reasonably expected. It provides an independent assessment of pressures and impact relationships, which is valuable especially if emission and abstraction registers are poorly populated. Clearly the use of GIS facilitates this process.

5.4 Identification of significant pressures

The inventory of pressures is likely to contain many that have no or little impact on the water body. The assessment of whether a pressure on a water body is significant must be based on knowledge of the pressures within the catchment area, together with some form of conceptual understanding, of water flow, chemical transfers, and biological functioning of the water body within the catchment system. In other words there must be some knowledge that a pressure may cause an impact because of the way the catchment system functions. This understanding coupled to the list of all pressures and the particular characteristics of the catchment makes it possible to identify the significant pressures. However this approach often requires two stages:

- In the first one, correlation assessment can be carried out. It has the advantage of using monitored data and does not require complex hypotheses.

- In the second approach the conceptual understanding is embodied in a set of simple rules that indicate directly if a pressure is significant. One approach of this type is to compare the magnitude of the pressure with a criterion, or threshold, relevant to the water body type. Such an approach cannot be valid using one set of thresholds across Europe since this fails to recognise the particular characteristics of the water body and its vulnerability to the pressure. This approach effectively combines the pressure identification with the impact analysis since, if any threshold is exceeded, the water body is assessed as likely to fail its objectives. While simple, these methods can be an effective method of encapsulating expert judgement, and be based on sound science

To improve confidence, the estimates of the type and magnitude of pressures should be crosschecked, where possible, with monitoring data and with information on the key drivers for the pressures.
5.5  Assessing the impacts of pressures

As already mentioned in Chapter 4.1 the initial characterisation includes the identification of pressures and the assessment of the risk of failing to achieve objectives. Within the initial characterisation it is suggested that the concept of ‘potential impact’ is introduced to describe the effects that a pressure is likely to have on a groundwater body, and that potential impact is used in the evaluation of whether the body is ‘at risk’. This concept recognises that, with the constraints on the characterisation process, it will not always be possible to accurately measure the impact by monitoring groundwater levels and quality. For pollution pressures the potential impact is judged by considering the pollution pressure (where this occurs at the surface) in combination with the vulnerability of the groundwater body to pollution. Thus, for example, a high pollution pressure caused by anthropogenic activities at the surface may have little impact on a groundwater body if that body is protected by a significant thickness of low permeable layers.

Within the further characterisation a ‘review of the impact of human activity’ for groundwater bodies characterised to be ‘at risk’ and for those crossing Member State boundaries is required. The approach recommended follows that outlined for the initial characterisation, but requires the collection of more detailed information and data. The wording of Annex II suggests that the information specified shall be included ‘where relevant’. In this context ‘relevant’ is taken to mean relevant to the assessment of risk of failure to meet Article 4 objectives.

5.5.1  Tools to assist assessing the impacts

Assessing the impacts on a water body requires some quantitative information to describe the state of the water body itself and/or the pressures acting on it. The type of analysis will be dependent on what data are available. Regardless of the particular process to be adopted, and as with the identification of significant pressures described above, the assessment requires a conceptual understanding of what causes impacts. In many cases a simple approach might be absolutely suitable for assessing the impact of a pressure. However, there will be a vast range of catchment types, water body types, interacting pressures, process conceptualisations, data requirements and possible impacts, and adopting such a simple model for all cases might not be appropriate. Tools which might assist assessing the impacts comprise the use of observed data to assess and to refine the assessment, a conceptual model, the use of analogue water bodies and the use of numeric models.

A pressure checklist can be considered as a reminder of the driving forces and the pressures that should be considered and therefore represents a precursor to the actual pressures and impacts analysis.

If monitoring data are available for the water body itself, it might be possible to perform a direct assessment of the impact. But, it must be kept in mind that most pressures do not create a clear-cut impact. Monitoring data may indicate that there are no current impacts. This information itself reveals that none of the pressures identified in the initial screening process is significant, or that the time lag required for a pressure to give rise to an impact has not yet passed. The latter is likely to be of particular importance when assessing groundwater bodies in which pollutants travel very slowly.

A conceptual model/understanding of the flow system, chemical variations and the interaction between groundwater and surface ecosystems is essential for characterisation. A significant strength of the approach is that it allows a wide variety of data types (including, for example physical, biological and chemical data) to be integrated into a coherent understanding of the system. As new data are obtained they help to refine, or change, the model; conversely the model may indicate errors and inadequacies in the data (see Chapter 5.2). A further step could be the shift to mathematical models only where water bodies appear to be at risk, or where a detailed programme of measures is being developed. In general the more complex the model, the greater the data requirements and the greater the time and costs needed to improve it. However, in the context of water body characterisation under the WFD there are many questions that may be answered adequately with a simple model.

In situations with no observed data, one possible means to evaluate status is to use a similar analogous site for which data are available, and to assume that the assessment made from the
observed data can be applied validly to both sites. Furthermore, the WFD offers the possibility of grouping water bodies for the purpose of pressure and impact analysis and monitoring.

### 5.5.2 National and regional approaches for groundwater risk assessment

Most of the countries and regions combined screening approaches considering pressures data, vulnerability information and monitoring data. In the Netherlands a modelling approach was applied.

England and Wales combined pressure exposure and vulnerability information together with measured data. A large number of ‘at risk’ groundwater bodies was expected where further characterisation should resolve this uncertainty. In the Shannon PRB in Ireland the assessment relied on pressures and vulnerability assessment as well. Monitoring data were used for validating the assessment. In the Piemonte region in Italy the assessment relied on vulnerability and pressure analysis only.

Sweden as well as Lower Saxony (Germany) combined data on pressures with monitoring data and Hungary applied a screening approach focusing on pressures only where certain limits qualify as screening limits for assigning groundwater bodies at risk. The Netherlands assessed the risk by modelling the flux of water and chemicals from soil to draining surface waters. The uppermost horizon (1 m below surface) was therefore used as an early warning level subject of risk and trend assessment.

### 5.6 Evaluating the likelihood of failing to meet the objectives

In theory, evaluating the risk of failing objectives should be a straightforward comparison of the state of the water body with quality standards or threshold values (as defined in the new Groundwater Directive under negotiation) that define the objective.

The use of monitoring data for evaluating the risk of failing to achieve good chemical status needs careful consideration, having regard to the specific environmental objective(s) that could lead to a failure to achieve good status. It is clear that the process of evaluating the risk of failure is to some degree an iterative collaboration between those undertaking the pressures and impact analysis, and those defining thresholds for the as yet undefined elements of status (Figure 7).

![Figure 7: The iterative evaluation of the risk of failing objectives](image)

### 5.7 Relevant considerations

#### 5.7.1 Scaling issues

Different kinds of pressures do not impact the different water bodies at the same time and space scales. It is important to adopt appropriate temporal scales in the pressures and impacts analysis since some pressures may result in impacts many years in the future, and some future impacts will relate to past pressures that no longer exist. For example, pesticide application may lead to increased concentrations of the pesticide in the groundwater many years after it was released. When
a groundwater body currently has good status but it is thought that pressures may cause its status to be rendered poor by 2015, then the body is ‘at risk’ and will require further characterisation. It should be noted that a body currently determined to have poor status will automatically be ‘at risk’.

Regarding spatial scales, the important features of data are the location, especially if the water body comprises very different components (e.g. recharge area of a confined groundwater etc.) that respond differently to the pressure. Pressure location can be analysed as precise information or as density information. In the first case, the relevant component of the water body is identified. In the latter, the area on which the pressure is exerted must be identified and small enough to make it possible to link the pressure to its target. For example, considering confined groundwater, the important data is the emissions on the recharge area only, not over the total extent of the water body.

The WFD does not differentiate between groundwater in different strata – all groundwater requires the same degree of protection from pollution. However, the impact that a pollution pressure is likely to have on groundwater varies from site to site, depending on the hydrogeological properties of the underlying soil, drift and solid geological strata. Consequently, for a given pollution pressure, the impact on the status of a groundwater body, and the potential programme of measures will vary in different aquifers.

5.7.2 Uncertainty and refinement of assessment

The first pressures and impacts analyses had to be complete by the end of 2004. However, the environmental conditions required to meet most of the Directive’s objectives have not been firmly defined by this date as elements of the groundwater objectives await clarification in the Article 17 Daughter Directive. The confidence and precision in the estimated environmental effects of different pressure types will also be very variable, depending to a great extent on the quality of national and local information and assessment expertise. This is because consideration of many of the pressures and impacts relevant under the Water Framework Directive has not previously been required by other Community water legislation.

Member States completed the first analyses using appropriate estimates for pressures and impacts but they had to be aware, and had to take account of, the uncertainties in the environmental conditions required to meet the Directives’ objectives and the uncertainties in the estimated impacts. The consequence of these uncertainties is that Member States’ judgements on which bodies are at risk, and which are not, are likely to contain more errors in the first report than will be the case in subsequent planning cycles. It will be important for Member States to be aware of the uncertainties so that their monitoring programmes can be designed and targeted to provide the information needed to improve the confidence in the assessments. Where the assessment contains significant uncertainty, those water bodies should be categorised as at risk of failing to meet their objectives. Obvious failing of pressures is not an uncertainty.

5.8 Reporting on the pressure and risk analysis

Article 15 (2) requires Member States to submit a summary report of the pressures and impact analyses to the Commission within three months of their completion (i.e. the first report had to be submitted by March 2005).

The summary reports sent to the Commission should be concise and give an overview of relevant characteristics and main water bodies within a River Basin District (RBD), tables and maps showing significant pressures and water bodies at risk. Furthermore, the summary report should include methodologies, tools, thresholds, environmental quality objectives, classification schemes etc. used within the risk assessment and an indication of the amount of uncertainty of the pressure analysis and results.

More detailed information should be available on demand for public and stakeholder consultation.
Working Group D is developing guidance on reporting to the Commission in the form of reporting sheets for the single reporting obligations of the WFD. This will contribute to the provision of a comparable basis for harmonization of water management on a river basin scale between countries within international RBDs and to provide a transparent overview of the analysis and results to communicate with government, stakeholders and the public. Moreover, the development of WISE (Water Information System for Europe) will enable electronic reporting and visualisation of reported data (system aimed to be publicly opened by the end of 2006), see section 7 of this report.

6 Groundwater monitoring

The WFD requires the establishment of monitoring programmes covering groundwater quantitative status, chemical status and the assessment of significant, long-term pollutant trends resulting from human activity by 22 December 2006 at the latest. The monitoring of groundwater chemical status is distinguished in surveillance and operational monitoring. The Directive sets out its requirements for the different groundwater monitoring programmes in Annex V.

The programmes must provide the information necessary to validate the Article 5 risk assessment procedure and to assess the achievement of the Directive’s objectives for groundwater. The programmes may need to be supplemented by additional monitoring to meet requirements relevant to Protected Areas (e.g. Drinking Water Protected Areas [DWPA]).

The results of the monitoring must be used to:
- assist in further characterisation of groundwater bodies;
- validate the risk assessments carried out under Article 5;
- establish the chemical and quantitative status of groundwater bodies (including an assessment of the available groundwater resource);
- estimating the direction and rate of flow in groundwater bodies that cross Member States boundaries;
- assist the design of programmes of measures;
- evaluate the effectiveness of programmes of measures;
- demonstrate compliance with DWPA and other protected area objectives
- characterise the natural quality of groundwater including natural trends (baseline) and;
- identify anthropogenically induced trends in pollutant concentrations and their reversal.

6.1 General principles

The monitoring programmes must provide the information necessary to assess whether the Directive’s environmental objectives will be achieved. This means that a clear understanding of the environmental conditions required for the achievement of the objectives, and of how these could be affected by human activities, is essential to the design of effective monitoring programmes. The monitoring programmes should therefore be designed on the basis of the results of the Article 5 characterisation and risk assessment procedure and the conceptual model/understanding of the groundwater system. Figure 8 outlines the principles and relationship of the model to the monitoring programme (for the conceptual model see also Chapter 5.2).

It should be emphasised that the WFD monitoring is intended to focus at phenomena affecting the overall state of the groundwater body. Local scale pollution processes which do not affect the overall state of the groundwater body should be the target of different monitoring activities run by the competent institution (local, regional ...) concerned; they are not relevant to the European level network unless their evolution in time and space endanger the quality objectives at the macro system level.
6.1.1 Integrated monitoring

The WFD considers the water environment as a continuum. This is reflected in the groundwater status definitions and through the recognition of the role played by groundwater in maintaining the flow, quality and ecology of dependent surface waters. Therefore as well as providing an overview on the distribution of contaminants in the body of groundwater, monitoring must be able to provide an understanding and assessment relating to groundwater flows between groundwater bodies and surface water bodies and between groundwater bodies and terrestrial ecosystems. The extent of this monitoring will depend on the significance of the dependency of the surface water bodies and/or terrestrial ecosystems on groundwater and the extent of the risks.

Monitoring programmes for surface water and groundwater should therefore be designed and operated in an integrated way where the environmental objectives of surface waters and groundwater are dependent on each other. Monitoring data from surface water bodies may be important in assessing the status of groundwater bodies. Surface waters with a large base flow can be used to indicate the quality of groundwater. The effects of human alterations to groundwater quality and levels on the status of large base flow surface waters are also likely to be larger than the effects of the same alterations on the status of low base flow surface waters.

Designing and operating integrated groundwater and surface water monitoring networks will also contribute significantly to cost-effective monitoring.

6.1.2 Grouping of groundwater bodies

Groundwater bodies may be grouped for monitoring purposes provided that the monitoring information obtained provides for a reliable assessment of the status of each body in the group and the confirmation of any significant upward trends in pollutant concentrations.

Groundwater bodies maybe grouped if they are sufficiently similar in terms of aquifer characteristics, pathway susceptibility(ies), pressure(s) and confidence in the risk assessment(s). In grouping groundwater bodies, the monitoring programmes must be designed and operated to ensure that the environmental and monitoring objectives for each of the component bodies making up the group can be reliably achieved. The criteria for grouping and monitoring might be different for groups of groundwater bodies being at risk and being not at risk.
6.1.3 Dependency to compliance regime

The requirements on monitoring can not only be derived from the WFD directly but depend on the algorithms which are applied by Member States to implement the Directive and comply with its objectives. The WFD does not exactly prescribe the assessment methods to be used. In fact it is the individual duty of the Member States to decide on the algorithms applied in order to perform the required assessments. The correct implementation of appropriate methods imply that certain method specific requirements on the monitoring have to be met which is then reflected by the precision and the confidence of the assessment results.

6.1.4 Network update

According to the results and the improvement of the conceptual understanding the network design should be reviewed and adapted if required. Network updating should take into account the variations encountered in the natural and/or anthropogenic processes, trends, emerging phenomena. Updating of the network setting should be performed every time the factors influencing the observed phenomena change significantly.

6.2 Chemical status and trend monitoring

Groundwater quality monitoring carried out in accordance with the WFD should be designed to answer specific questions and support the achievement of the environmental objectives. The principal purposes of groundwater quality monitoring are to (a) provide information for use in classifying the chemical status of groundwater bodies or groups of bodies; (b) establish the presence of any significant upward trend in pollutant concentrations in groundwater bodies and the reversal of such trends and (c) ensure compliance with Protected Area objectives.

The requirements of good groundwater chemical status are threefold:

1. **General water quality**: The concentration of pollutants should not exceed the quality standards applicable under other relevant Community legislation in accordance with Article 17;
2. **Impacts on ecosystems**: The concentration of pollutants should not be 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; and
3. **Saline intrusion**: The concentrations of pollutants should not exhibit the effects of saline or other intrusions as measured by changes in conductivity;

All three criteria must be met for a body to achieve good groundwater chemical status. The classification of groundwater chemical status is only concerned with the concentrations of substances introduced into groundwater as a result of human activities.

The WFD stipulates that surveillance monitoring must be undertaken during each planning cycle, and operational monitoring must be carried out during periods not covered by surveillance monitoring. No minimum duration or frequency is specified for the surveillance programme. Operational monitoring must be carried out at least once a year during periods between surveillance monitoring. Member States should undertake sufficient surveillance monitoring during each plan period to allow adequate validation of the Article 5 risk assessments and obtain information for use in trend assessment, and sufficient operational monitoring to establish the status of bodies at risk and the presence of significant and sustained upward trend in pollutant concentrations.
6.2.1 Surveillance monitoring

A surveillance monitoring programme is required to:

- **Validate risk assessments**: supplement and validate the characterisation and risk assessment procedure with respect to risks of failing to achieve good groundwater chemical status;
- **Classify groundwater bodies**: confirm the status of all groundwater bodies, or groups of bodies, determined as not being at risk on the basis of the risk assessments; and
- **Assess trends**: provide information for use in the assessment of long-term trends in natural conditions and in pollutant concentrations resulting from human activity.

The surveillance monitoring programme will also be useful for defining baseline conditions and characteristics within the groundwater body.

Surveillance monitoring must be carried out during each plan period and to the extent necessary to adequately supplement and validate the risk assessment procedure for each body or group of bodies of groundwater, both at risk and not at risk of failing WFD objectives.

**Where to monitor**

Information on pressures, the conceptual model/understanding of the groundwater system, the fate and behaviour of pollutants in it and the consequent risks to the objectives should be used to determine the most appropriate locations for monitoring points. It should be further kept in mind that contaminants are generally unevenly distributed in a body of groundwater. Spatial distributions of contaminants are often closely linked to the location of different pressures, e.g. point and diffuse sources (different types of land use). Additionally a body of groundwater is a three dimensional object. The concentration of contaminants may vary with depth within one aquifer and generally differs in (overlying) aquifers within the same body of groundwater. Furthermore the physico-chemical parameters (e.g. conductivity, temperature and concentration of contaminants) in shallow aquifers sometimes reveal a distinct variation within the year.

So the selection of sampling sites, sampling depth and even the time of sampling may highly influence the results of the assessment of the status of groundwater.

**What to monitor**

The Directive requires a core set of parameters to be monitored, comprising dissolved oxygen, pH, electrical conductivity, nitrate and ammonium. Additional parameters must be selected on the basis of the identified pressures and the risk assessments made to supplement and validate the Article 5 risk assessments.

When assessing natural background levels, additional selective determinands (e.g. heavy metals and radionuclides) will be required for the purposes of characterising natural groundwater quality and trends.

Transboundary water bodies shall also be monitored for those parameters which are relevant for the protection of all of the uses supported by the groundwater flow.

**When to monitor**

The conceptual model/understanding of the groundwater system, the characteristics of the aquifer and the understanding of the fate and behaviour of pollutants within it, suggests the appropriate frequency of monitoring. Monitoring frequencies that Member States have found appropriate in a number of hydrogeological circumstances and in relation to different pollutant behaviours range from quarterly monitoring to monitoring every 6 years. It should be kept in mind that a sampling frequency of less than once a year seems to be inadequate for trend assessment.
6.2.2 Operational monitoring

Operational monitoring is required to classify the status of bodies ‘at risk’ as either poor or ‘good’ status or to establish the presence of significant upward trends in pollutants. Operational monitoring is required only in bodies ‘at risk’ of failing to meet WFD objectives. It should be carried out during the period between surveillance monitoring. In contrast to surveillance monitoring, operational monitoring is highly focussed on assessing the specific, identified risks to the achievement of the Directive’s objectives. Operational monitoring programmes must be designed on the basis of the characterisation and risk assessment as refined by the data from the surveillance monitoring programmes.

In designing an operational monitoring programme, the required confidence in the monitoring results must be defined. The required confidence in operational monitoring depends upon the variability of the impact source and the groundwater or aquifer properties in question, as well as the risk in case of error.

Where to monitor

The process of selecting sampling sites will be based on the characterisation and conceptual model(s) including an assessment of aquifer, pathway susceptibility and receptor sensitivity. It should take into regard the assessment of risk and the level of confidence in the assessment; including the distribution of key pressures identified in the characterisation process and which may cause the body to be classified at poor status.

Where risk issues relate to specific receptors such as ecosystems, additional sampling points can be focussed in areas that are close to these receptors. In these cases where the location of pressures (point sources) is well known, sampling points will often be used to help isolate impacts from different pressure types. Where pressures and risk issues relate to the groundwater itself, e.g. diffuse pressures, sampling points will be more distributed across the body, and will be focused on the different pressures and their distribution within the groundwater body.

What to monitor

In most cases, both core and selective determinands will be required at each sampling station. The selection of determinands will be based on the initial conceptual models, the ongoing risk assessments arising out of WFD risk characterisation and results of the ongoing monitoring programmes. In practice, selected determinands should correspond to all the pollutants which have been identified as representing a risk to groundwater in the framework of the WFD Article 5 analysis of pressures and impacts.

When to monitor

Monitoring frequency will generally be based on the conceptual model and in particular, the characteristic of the aquifer and its susceptibility to pollution pressures. Suggested minimum frequencies for monitoring at different aquifer types range from quarterly to annual monitoring.

Sampling frequency and timing also depend on the requirements for trend assessment, whether the location is up-gradient, directly below, or down-gradient of a pressure where locations directly below a pressure may require more frequent monitoring. Furthermore, the level of confidence in the WFD risk assessments, changes in the assessments over time, and seasonal effects should be taken into regard.

How long

Sampling for operational monitoring must be continued until the groundwater body is determined, with adequate confidence, to be no longer at poor status or at risk and there is adequate data to demonstrate a reversal of trends.
6.3 Quantity monitoring

A quantitative monitoring network is required to assist in characterisation, to determine the 'quantitative status' of groundwater bodies, and to support the design and evaluation of the programme of measures.

The Directive’s requirements for good groundwater quantitative status are three-fold:

- There is a requirement to ensure that the available groundwater resource for the body as a whole is not exceeded by the long-term annual average rate of abstraction;
- Abstractions and other anthropogenic alterations to groundwater levels should not adversely affect associated surface water bodies and terrestrial ecosystems that depend directly for their water needs on the body of groundwater; and
- Anthropogenic alterations to flow direction must not have caused, or be likely to cause, saltwater or other intrusion.

As with other networks, the monitoring design should be based on a conceptual understanding of the groundwater system and the pressures. The key elements of the quantitative conceptual understanding will be:

- assessments of recharge and the water balance; and/or
- existing GW-level or discharge assessments and relevant information on the risks for groundwater dependant surface water bodies and terrestrial ecosystems;
- the degree of interaction between groundwater and related surface and terrestrial ecosystems.

The quantitative monitoring network shall:

- provide a reliable assessment of the quantitative status of all groundwater bodies or groups of bodies including an assessment of the available groundwater resource;
- supplement and validate the Article 5 characterisation and risk assessment procedure with respect to risks of failing to achieve good quantitative status in all bodies or groups of bodies of groundwater;
- take into account short and long-term variations in recharge when estimating the groundwater level and assessing the quantitative status of each groundwater body;
- assess the impact of abstractions and discharges on the groundwater level for groundwater bodies identified as being at risk;
- estimate the direction and rate of groundwater flow across the Member State boundary for groundwater bodies within which groundwater flows across a Member State boundary.

Where to monitor

The choice of where to monitor will depend on what is needed to test the conceptual model/understanding and the predictions it provides. In principle, the more spatially variable the groundwater flow system or the pressures on it, the greater the density of monitoring points that will be required to provide the data needed to make suitably confident assessments of the status of a groundwater body, or group of bodies.

Additional monitoring to support groundwater characterisation and classification may also include:

- chemical monitoring for saline or other intrusions;
- rainfall and the components required to calculate evapotranspiration (to calculate groundwater recharge);
- ecological monitoring of groundwater dependent terrestrial ecosystems (including ecological indicators);
- groundwater abstraction (and artificial recharge).
What to monitor

Although the Directive identifies groundwater level as the metric for determining quantitative status, in practice, the most appropriate parameters to monitor quantitative status will depend on the conceptual model/understanding of the groundwater system. For example, spring flows or even base-flows in rivers may be more appropriate than the use of boreholes in low permeability fractured media or where the risks of failing to achieve good quantitative status are low and information from the surface water monitoring network can adequately validate this assessment.

When to monitor

The most appropriate monitoring frequency will depend on the conceptual model/understanding of the groundwater system and the nature of the pressures on the system. The frequency chosen should allow short-term and long-term level variations within the groundwater body to be detected. For example, for formations in which the natural temporal variability of groundwater level is high or in which the response to pressures is rapid, more frequent monitoring will be required than will be the case for bodies of groundwater that are relatively unresponsive to short-term variations in precipitation or pressures. Where monitoring is designed to pick up seasonal or annual variations, the timing of monitoring should be standardised from year to year.

6.4 Monitoring of protected areas

The Water Framework Directive establishes a planning framework to, among other things, support the achievement of the standards and objectives for Protected Areas established under Community legislation. In the context of groundwater, these areas may include Natura 2000 sites established under the Habitats Directive (92/43/EEC) or the Birds Directive (79/409/EEC), Nitrate Vulnerable Zones established under the Nitrates Directive (91/676/EEC) and Drinking Water Protected Areas established under Article 7 of the Water Framework Directive.

To ensure monitoring programmes are as efficient and as effective as possible, it would be appropriate to ensure that the quantitative and the chemical monitoring programmes described above complement, and are integrated with, the programmes established for Protected Areas so that the groundwater monitoring networks are as far as possible multi-purpose.

The achievement of the Drinking Water Protected Area objective requires preventing deterioration in the water quality to reduce the level of treatment for meeting the standards of the Drinking Water Directive. This requires that this analysis should take account of any parameters that could affect the level of treatment required to produce drinking water.

Regular monitoring of all potable sources would not be practical or necessary where the characterisation processes has indicated no risk. There should be sufficient monitoring of a representative selection of significant potable sources to confirm the risk assessment. This should be incorporated into and may in practice already be part of the surveillance monitoring programme. Since drinking water wells are often located in areas that have better GW-quality a representative selection of sites may be monitored to avoid bias in the assessment for Drinking Water Protected Areas.

6.5 Quality assurance / Quality control

The confidence in any assessment of groundwater will depend on the confidence in the conceptual model/understanding of how pressures are interacting with the groundwater system. The confidence in any model needs to be evaluated by testing its predictions with monitoring data. However, errors in the monitoring data could lead to errors in the evaluation of the reliability of the conceptual model/understanding.

Achieving quality in the context of measurement data means that data quality requirements as stated in directives are satisfied. A definition of the purpose of groundwater sampling is an essential prerequisite before identifying the sampling strategies and methods. Sampling design includes:
selection, construction and design of sampling sites, frequency and duration of sampling, sampling procedures, treatment of samples and analytical requirements.

Errors inevitably occur both in the process of sampling and in the analysis of water samples. The aim of an appropriate quality assurance procedure is to quantify and control these errors. Therefore, when requesting monitoring data from laboratories, these data quality requirements (particularly uncertainty) should clearly be defined. The laboratory can only provide good quality data when its activities are carried out under a quality system. Quality assurance procedures may take the form of standardisation of sampling and analytical methods, replicate analyses, ionic balance checks on samples and laboratory accreditation schemes. A continuous quality assurance system should be developed to ensure that all monitoring results meet assured target levels of precision and bias. Therefore, quality assurance measures should be implemented for each monitoring institution as well as in data collection centres, which encompass all operational facets of a monitoring programme.

In routine monitoring, quality assurance should ensure at any time that the methods used are strictly controlled and monitored. It is generally accepted that approximately 25% of a laboratory's effort is required to establish and maintain an effective quality assurance system.

Methods standardised by ISO, CEN or national standardisation bodies should be used as far as they are available. When no validated-by-a-standardisation-body method exist the laboratory has to validate the method used and should provide the documentation describing the method for an unambiguous and easy implementation and for its validation.

To evaluate the comparability of monitoring data throughout the Member States, participation in external quality audits and in external quality assessment schemes like international laboratory proficiency testing or taxonomical workshops is highly recommended.

This issue is currently under discussion in a new expert group under the “Chemical Monitoring Activity” of the Common Implementation Strategy of the WFD, which aims to develop monitoring guidance documents including method’s performance criteria and recommendations.

6.6 Reporting on the monitoring

Member States have to submit summary reports of the monitoring programmes within three months of their completion in 2006 (i.e. by March 2007).

The results of monitoring must be used to estimate the chemical and quantitative status of bodies of groundwater which has to be reported in the management plans. The results of monitoring should also assist in designing programmes of measures, testing the effectiveness of these measures and informing the setting of objectives. Later on monitoring results should be used in the reviews of the Article 5 risk assessment procedure.

The confidence and precision in the monitoring results obtained must be reported and held against the required confidence as defined in the design of a monitoring programme. The confidence in the status classifications included in the first plan might be lower than in subsequent plans as the assessment is rather based on surveillance monitoring than on operational monitoring.

The reported confidence must as a minimum describe the uncertainty arising from the monitoring processes and the variability (in time or space) of the parameters monitored. If the initially required confidence has not been obtained, the consequences for the monitoring objectives must be evaluated and the need for adjustment of the monitoring programme specified.

The documentation of the monitoring programme and the content of summary reports to be submitted to the European Commission are being discussed in WG D ‘Reporting’ which is currently developing ‘Reporting Sheets’. It comprises summary information in ‘verbal’ form like investigated parameters and monitoring frequency and information in table structure.
7 Outlook

The Common Implementation Strategy (CIS) of the WFD and Working Group C ‘Groundwater’

The Water Directors endorsed the WFD Common Implementation Strategy (CIS) Work Programme for 2005/2006, which includes the priorities and specific mandates for the different working groups that are part of the CIS.

Regarding groundwater the process will serve as an exchange platform to address issues of practical relevance. According to the mandate of WG C which was adopted by the Water Directors the goal of the group is to elaborate groundwater guidance documents for the implementation of the WFD and the forthcoming Groundwater Directive. The document should be adopted before the end of 2006. Already existing guidance documents should not be duplicated. It was stressed that clear and pragmatic approaches should be developed (simple text) complemented by case studies. Since the Groundwater Directive is still under negotiation at the European Parliament and the Council, main focus will be given on issues already covered by the WFD and with direct impact on Groundwater Directive compliance. Hence it could be necessary to adapt the guidance after adoption of the Groundwater Directive.

Four drafting groups were foreseen, namely on ‘monitoring’, ‘protected areas’, on ‘direct and indirect inputs’ and on ‘status and trends’. Furthermore a ‘Mediterranean Group’ is linking with the ‘water scarcity’ expert group.

Water Information System Europe (WISE)

The EU bodies (DG ENV, JRC, ESTAT and EEA) and EU25 Member States, Norway, Bulgaria and Romania recognised a need for ‘streamlining’ the reporting process, gathering more useful and relevant information and making the exchange process as efficient as possible using modern technology (i.e. web based reporting). They agreed on the Water Directors’ meeting in November 2003 upon the development of a new, comprehensive, shared European data and information management system for water, including river basins (WISE). This presents opportunities for rationalising the information collected and thus reduces the reporting burden on Member States.

WISE will cover all water-related information coming from EU water policy (not only the Water Framework, but also the Urban Wastewater Treatment, Nitrates, Bathing Water and Drinking Water Directives as well as the upcoming Marine Strategy and the Flood Action Programme) and it should be extended to cover other European water-related datasets (such as EIONET Water and water research information). By geo-referencing most of these data, WISE will become an important building block for INSPIRE, another European Community initiative.

This system is currently being developed with close links to the on-going development of the INSPIRE directive and related implementation rules.