European Commission

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

Guidance document n.° 9

Implementing the Geographical Information System Elements (GIS) of the Water Framework Directive

COMMON IMPLEMENTATION STRATEGY FOR THE WATER FRAMEWORK DIRECTIVE (2000/60/EC)

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Implementing the Geographical Information System Elements (GIS) of the Water Framework Directive

Produced by Working Group 3.1 – GIS

Disclaimer:

This technical document has been developed through a collaborative programme involving the European Commission, all the Member States, the Accession Countries, Norway and other stakeholders and Non-Governmental Organisations. The document should be regarded as presenting an informal consensus position on best practice agreed by all partners. However, the document does not necessarily represent the official, formal position of any of the partners. Hence, the views expressed in the document do not necessarily represent the views of the European Commission.

A great deal of additional information on the European Union is available on the Internet.
It can be accessed through the Europa server (http://europa.eu.int).

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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 (the Water Framework Directive). 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.

One of the main short-term objectives of the strategy is the development of non-legally binding and practical Guidance Documents on various technical issues of the Directive. These Guidance Documents are targeted to those experts who are directly or indirectly implementing the Water Framework Directive in river basins. The structure, presentation and terminology are therefore adapted to the needs of these experts and formal, legalistic language is avoided wherever possible.

In the context of the above-mentioned strategy, a working group dedicated to the development of technical specifications for implementing a Geographical Information System (GIS) for the reporting needs of the Water Framework Directive has been established in September 2001, referred to as GIS-WG. The Joint Research Centre (JRC) had the responsibility to co-ordinate and lead this working group, which included representatives from most Member States, some candidate countries, the Commission, Eurostat, and the EEA.

The present Guidance Document is the outcome of this working group. It contains the synthesis of the output of the GIS-WG activities and discussions. It builds on the input and feedback from a wide range of experts that have been involved throughout the process of guidance development through workshops or electronic communication media, without binding them in any way to its content.

We, the Water Directors of the European Union, Norway, Switzerland and the countries applying for accession to the European Union, have examined and endorsed this guidance during our informal meeting under the Danish Presidency in Copenhagen (21-22 November 2002). We would like to thank the participants of the Working Group and, in particular, the leader, Dr. Jürgen Vogt (JRC), for preparing this high quality document.

We strongly believe that this and other Guidance Documents developed under the Common Implementation Strategy will play a key role in the process of implementing the Water Framework Directive.

This Guidance Document is a *living document* that will need continuous input and improvements as application and experience build up in all countries of the European Union and beyond. We agree, however, that this document will be made publicly available in its current form in order to present it to a wider public as a basis for carrying forward ongoing implementation work.

Moreover, we welcome that several volunteers have committed themselves to test and validate this and other documents in the so-called pilot river basins across Europe during 2003 and 2004 in order to ensure that the guidance is applicable in practice.

We also commit ourselves to assess and decide upon the necessity for reviewing this document following the pilot testing exercises and the first experiences gained in the initial stages of the implementation.

Table of Contents

List of Figures (excluding appendices)

List of Tables (excluding appendices)

Introduction - A Guidance Document: What For?

This document aims at guiding experts and stakeholders in the implementation of the Directive 2000/60/EC establishing a framework for Community action in the field of water policy (the Water Framework Directive – "the Directive"). It focuses on the implementation of its GIS elements in the broader context of the development of integrated river basin management plans as required by the Directive.

To whom is this Guidance Document addressed?

If this is your task, we believe the guidance will help you in doing the job, whether you are:

- ***Preparing the geographic datasets for the preparation of maps required by the Directive;***
- ***Preparing the final maps as requested under the Directive; or***
- ***Reporting the maps and GIS layers to the European Commission as required by the Directive.***

What can you find in this Guidance Document?

The common understanding on terms and on the role of GIS in the WFD

What are a map, a dataset with geographic datatype, a table, and data?
What are the GIS elements of the Water Framework Directive?
Where in the Directive are these elements made explicit or referred to?

The maps and GIS layers requested for reporting under the WFD

Which maps are to be reported to the European Commission and when?
What are the different GIS layers that make up these maps?
What are the level of detail and spatial accuracy expected from the data?
Which is the reference system to use for reporting the data?

How to validate the GIS layers

Which validation procedures should be employed in the validation step?
Which standards should be followed when validating data?

How to document the GIS layers

What are the metadata fields to deliver with each GIS layer?
Which standards are to follow when preparing the metadata?

How to report GIS layers to the European Commission

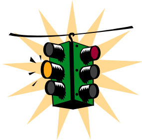
What is the format for transferring layers to the Commission in the short-term?
What is the way forward for the development of a distributed reporting system in the long-term?

How to harmonise data at borders and how to co-ordinate the reporting process

Which aspects should be considered for harmonising data at national borders and at borders of River Basin Districts?
How can a vertical integration between the various GIS layers be ensured?
How should the reporting process be co-ordinated?

How to introduce a European feature coding system

What are the advantages of implementing a European feature coding system?
What is the way forward for implementing a European feature coding system?



Look out! What you will not find in this Guidance Document

The Guidance Document focuses on the thematic content and technical specifications for the GIS layers to be prepared for reporting to the European Commission. The guidance does not focus on:

- *How to make maps out of the various GIS layers (layouts, symbols, generalisation procedures,…);*
- *How to use GIS in the analysis of pressures and impacts;*
- *How to use GIS in the preparation of river basin management plans.*

Historically, georeferenced data have been reported to the Commission in the form of analogue maps. With the introduction of Geographic Information Systems, these maps or the underlying GIS layers can now be reported in digital form.

In the European context experience with digital reporting is limited and standards are still under development. This Guidance Document, therefore, makes suggestions for best practices for the immediate reporting needs of the WFD and at the same time formulates strategies for the long-term needs. The recommendations will have to be tested and further developed over the next few years.

1 Implementing the Water Framework Directive

This Section introduces you to the overall context for the implementation of the Water Framework Directive and informs you of the initiatives that led to the production of this Guidance Document.

1.1 December 2000: A Milestone for Water Policy

A long negotiation process

December 22, 2000, will remain a milestone in the history of water policies in Europe: on that date, the Water Framework Directive (or the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) was published in the Official Journal of the European Communities and thereby entered into force!

This Directive is the result of a process of more than five years of discussions and negotiations between a wide range of experts, stakeholders and policy makers. This process has stressed the widespread agreement on key principles of modern water quality management that today form the foundation of the Water Framework Directive.

1.2 The Water Framework Directive: New Challenges in EU Water Policy

What is the purpose of the Directive?

The Directive establishes a framework for the protection of all waters (including inland surface waters, transitional waters, coastal waters and groundwater), which:

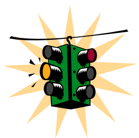
- Prevents further deterioration of, protects and enhances the status of water resources;
- Promotes sustainable water use based on long-term protection of available water resources;
- Aims at enhancing protection and improvement of the aquatic environment through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;
- Ensures the progressive reduction of pollution of groundwater and prevents its further pollution; and
- Contributes to mitigating the effects of floods and droughts.

… and what is the key objective?

Overall, the Directive aims at achieving *good water status* for all waters by 2015.

What are the key actions that Member States need to take?

- To identify the individual river basins lying within their national territory and assign them to individual River Basin Districts (RBDs) and identify competent authorities by 2003 (*Article 3, Article 24*);
- To characterise river basin districts in terms of pressures, impacts and economics of water uses, including a register of protected areas lying within the river basin district, by 2004 (*Article 5, Article 6, Annex II, Annex III*);
- To carry out, jointly and together with the European Commission, the intercalibration of the ecological status classification systems by 2006 (*Article 2 (22), Annex V*);
- To make operational the monitoring networks by 2006 (*Article 8*);
- Based on sound monitoring and the analysis of the characteristics of the river basin, to identify by 2009 a programme of measures for achieving the environmental objectives of the Water Framework Directive cost-effectively (*Article 11, Annex III*);
- To produce and publish River Basin Management Plans (RBMPs) for each RBD including the designation of heavily modified water bodies, by 2009 (*Article 13, Article 4.3*);
- To implement water pricing policies that enhance the sustainability of water resources by 2010 (*Article 9*);
- To make the measures of the programme operational by 2012 (*Article 11*);
- To implement the programmes of measures and achieve the environmental objectives by 2015 (*Article 4*).



Look Out!

Member States may not always reach good water status for all water bodies of a river basin district by 2015, for reasons of technical feasibility, disproportionate costs or natural conditions. Under such conditions that will be specifically explained in the RBMPs, the Water Framework Directive offers the possibility to Member States to engage into two further six- year cycles of planning and implementation of measures.

Changing the management process – information, consultation and participation

Article 14 of the Directive specifies that Member States shall encourage the active involvement of all interested parties in the implementation of the Directive and development of river basin management plans. Also, Member States will inform and consult the public, including users, in particular for:

- The timetable and work programme for the production of river basin management plans and the role of consultation, at the latest by 2006;
- The overview of the significant water management issues in the river basin, at the latest by 2007;
- The draft river basin management plan, at the latest by 2008.

Integration: a key concept underlying the Water Framework Directive

The central concept of the Water Framework Directive is the concept of *integration* that is seen as key to the management of water protection within the river basin district:

- **Integration of environmental objectives**, combining quality, ecological and quantity objectives for protecting highly valuable aquatic ecosystems and ensuring a general good status of other waters;
- **Integration of all water resources**, combining fresh surface water and groundwater bodies, wetlands, coastal water resources **at the river basin scale**;
- **Integration of all water uses, functions and values** into a common policy framework, i.e. investigating water for the environment, water for health and human consumption, water for economic sectors, transport, leisure, water as a social good;
- **Integration of disciplines, analyses and expertise,** combining hydrology, hydraulics, ecology, chemistry, soil sciences, technology engineering and economics to assess current pressures and impacts on water resources and identify measures for achieving the environmental objectives of the Directive in the most cost-effective manner;
- **Integration of water legislation into a common and coherent framework.** The requirements of some old water legislation (e.g. the Fishwater Directive) have been reformulated in the Water Framework Directive to meet modern ecological thinking. After a transitional period, these old Directives will be repealed. Other pieces of legislation (e.g. the Nitrates Directive and the Urban Wastewater Treatment Directive) must be co-ordinated in river basin management plans where they form the basis of the programmes of measures;
- **Integration of all significant management and ecological aspects** relevant to sustainable river basin planning including those which are beyond the scope of the Water Framework Directive such as flood protection and prevention;
- **Integration of a wide range of measures, including pricing and economic and financial instruments, in a common management approach** for achieving the environmental objectives of the Directive. Programmes of measures are defined in **River Basin Management Plans** developed for each river basin district;
- **Integration of stakeholders and the civil society in decision making,** by promoting transparency and information to the public, and by offering a unique opportunity for involving stakeholders in the development of river basin management plans;
- **Integration of different decision-making levels that influence water resources and water status,** be local, regional or national, for an effective management of all waters;
- **Integration of water management from different Member States,** for river basins shared by several countries, existing and/or future Member States of the European Union.

1.3 What is Being Done to Support the Implementation?

Activities to support the implementation of the Water Framework Directive are under way in both Member States and in countries candidate for accession to the European Union. Examples of activities include consultation of the public, development of national guidance, pilot activities for testing specific elements of the Directive or the overall planning process, discussions on the institutional framework or launching of research programmes dedicated to the Water Framework Directive.

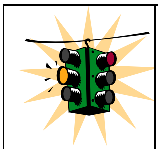
May 2001 – Sweden: Member States, Norway and the European Commission agreed a Common Implementation Strategy

The main objective of this strategy is to provide support to the implementation of the Water Framework Directive by developing coherent and common understanding and guidance on key elements of this Directive. Key principles in this common strategy include sharing information and experiences, developing common methodologies and approaches, involving experts from candidate countries and involving stakeholders from the water community.

In the context of this common implementation strategy, a series of working groups and joint activities have been launched for the development and testing of non-legally binding guidance. A strategic co-ordination group oversees these working groups and reports directly to the water directors of the European Union and Commission that play the role of overall guiding body for the Common Implementation Strategy.

The GIS Working Group

A working group has been created for dealing specifically with issues related to the implementation of a Geographical Information System. The main objective of this working group, short-named GIS-WG, was the development of a non-legally binding and practical guidance for supporting the implementation of the GIS elements of the Water Framework Directive, with emphasis on its 2003 and 2004 requirements. The members of the GIS-WG are experts from European Union Member States, from candidate countries to the European Union, from Eurostat, form the EEA, from the JRC and from DG Environment.



Look out! You can contact the experts involved in the GIS activities

A list of the GIS-WG members with full contact details can be found in Appendix XI. If you need input into your own activities, contact a member from the GIS-WG in your country. If you want more information on specific scoping and testing in pilot studies, you can also contact directly the persons in charge of carrying out these studies.

Developing the Guidance Document: an interactive process

Within a very short time period, a large number of experts have been involved at varying degrees in the development of this Guidance Document. The process for their involvement has included the following activities:

- *Organisation of **four workshops** of the 30-plus experts of the GIS-WG;*
- *Drafting and discussing of individual sections in task-groups;*
- *Exchange of documents for discussion and comments through email and the dedicated CIRCA web site;*
- *Inclusion of the opinion of a wide range of experts in the participating countries through their national representatives;*
- *Regular interactions with experts from other working groups of the Common Implementation Strategy through the participation of experts from other working groups in the WFD-GIS meetings, through the participation of WFD-GIS representatives in other WG meetings, or through email contacts;*
- *Set-up of a prototype GIS for testing the feasibility of some of the proposed specifications;*
- *Throughout the development of the guidance, the chairman of the working group attended regular meetings of the Strategic Co-ordination Group and of the Working Group Leaders in Brussels.*

2 GIS in the WFD: Developing a Common Understanding

This Section introduces the general basis for the detailed specifications as outlined in the following chapters. It reflects the common understanding of the working group experts on the purpose and the structure of the GIS elements to be developed as a basis for the reporting obligations under the Directive.

2.1 Terminology

In order to avoid ambiguity in terms, it is important to note that the following terminology will be used throughout this document:

Map: A graphical representation of a section of the Earth's surface. The Directive refers to a number of maps, each one with a specific thematic content (e.g., a map of the River Basin Districts). A map can be made up of one or many datasets with a geographic datatype. Using GIS software, maps can be presented in digital form from which an analogue map can be plotted. In this document, we assume that maps are produced in such a GIS environment and that they are made up of a set of digital datasets with a geographic datatype.

Dataset with a geographic datatype: A collection of data describing similar phenomena that can be represented with reference to the surface of the earth (e.g., the groundwater monitoring stations in a given River Basin District). In this document a dataset with geographic datatype is assumed to be a digital dataset in a GIS. The terms dataset, GIS layer or layer are used as synonyms for a digital dataset with a geographic datatype. The representation can be as pixels, points, lines, arcs and polygons or combinations of these.

Table: Most software systems require the organisation of datasets in one or more tables. In order to make information comparable between organisations, the structure of these tables must be similar.

Data: Tables are made up of digital data. The data will be stored using common typologies like geometry (e.g., points, lines, polygons, networks), strings (e.g., name, codes), numbers (e.g. amount of monitoring stations in a region), or dates (e.g., reporting date).

The relationship between these different levels of information is shown in Figure 2.1.1:

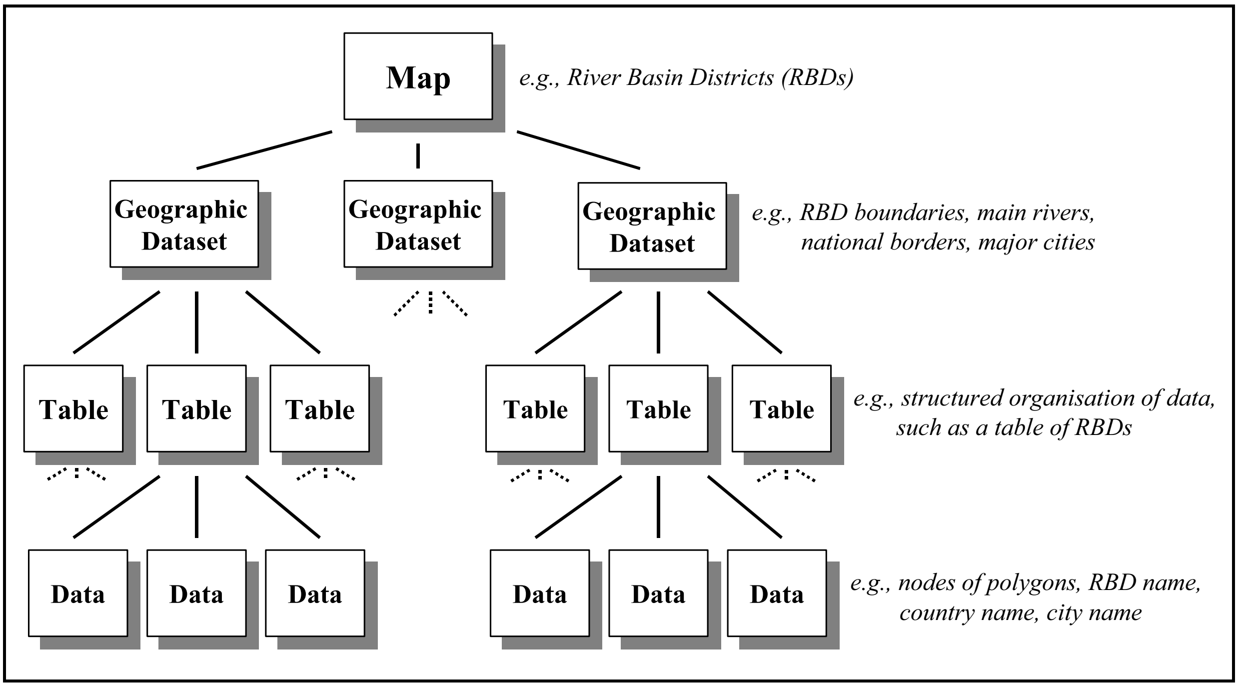


Figure 2.1.1: Relationship between a map, geographic datasets, tables and data.

2.2 GIS Requirements under the WFD and Scope of the Working Group

The WFD requires that Member States report a considerable amount of information in the form of maps. Even though only annex I and annex II of the Directive explicitly state that the respective maps should as far as possible be available for introduction into a GIS, it is obvious that the best way to provide most of the requested information will be in the form of GIS layers. This is due to the fact that most of the data is to be presented in its spatial context and that questions like ‘where are the critical areas?’, ‘how much area is involved?’, or ‘which points are in a designated area?’ can easily be answered when the data are kept in their spatial context and when the background database has the appropriate design.

The provision of (or access to) the requested GIS layers will not only facilitate the reporting of the Member States themselves; it will also facilitate the further compilation and analysis of the information as a basis for the Commission’s own reporting obligations under the WFD. Such development is also in line with current efforts under the INSPIRE (Infrastructure for Spatial Information in Europe) initiative of the Commission and the Member States, aiming at the development of a harmonised European spatial data infrastructure.

Many parties are involved in the implementation of the WFD, ranging from local water authorities to the European Commission. Regarding this wide range of parties, having different practices for water management, different reporting obligations and different levels of technical abilities, this Guidance Document strives to keep specifications as simple as possible, based upon standards where feasible, and according to best current technical options.

While the Directive clearly specifies which information should be provided in the form of maps (see appendix I of this Guidance Document), it gives little information on the technical specifications for these maps. The goal of the GIS working group under the Common Implementation Strategy, therefore, was to elaborate such specifications and to make them available in the form of this Guidance Document. The Guidance Document should help the Member States with the preparation of the GIS layers in such a way that they follow a common and agreed standard. This will not only facilitate the compilation of a European-wide picture, but it will also be a first step towards a more integrated spatial data infrastructure for Europe.

The implementation of the WFD requires the handling of spatial data both for the preparation of the River Basin Management Plans and for the reporting to the Commission. In the first case GIS techniques will be essential for the derivation of various information layers (e.g., on the characteristics of river basins and water bodies, on the chemical and ecological status of water bodies), while in the second case GIS will be the tool for the preparation and delivery of the GIS layers required for the reporting. Considering the limitations in time, the fact that many aspects of the analysis are still under discussion in other working groups, and the immediate needs stemming from the WFD implementation, it was decided that the current focus of the GIS Working Group should be on the WFD reporting obligations.

While this is a short-term goal, it is noted that in the long-term the development of specifications for a system including the possibility to access underlying measurements and statistical data or even for performing the various analyses as required for the preparation of the River Basin Management Plans might be considered. The elaboration of guidelines for these long-term options would, however, require substantial time and effort and is subject to a request by the Strategic Co-ordination Group for the Implementation of the WFD.

2.3 Reporting under the Water Framework Directive

The WFD is specifying which information should be reported in the form of maps and time schedules. This Guidance Document identifies these maps, the various GIS layers that are needed to make up these maps, their content and structure and how to document and to access or transfer them.

The WFD itself falls short in giving more detailed technical specifications with respect to the requested GIS layers. As a consequence, a common understanding had to be achieved on issues such as the contents of the various maps, the scale and positional accuracy of the data, and the reference system and projections to use. Given the fact that the various GIS layers will be part of a European picture, it was further necessary to consider issues such as the harmonisation at boundaries and the use of common identifiers. Recommendations are further given on the standards to be implemented for data exchange and data access and on the content and structure of the metadata to accompany each layer.

Technical possibilities nowadays allow the required GIS layers to be provided in two different ways. One option is to transfer them into a centralised system, where they will be stored, quality checked and analysed. The other option is to leave them at their place of origin (i.e. to store the data sets locally in each river basin district or country) and to guarantee access to these data through common standards and protocols. While the first option is easier to implement, the second option will reduce the burden of transferring data. However, it also asks for detailed technical specifications for the set-up and maintenance of a distributed system, which is more complicated. The GIS Working Group has explored both options. Given the limited time available to prepare the first GIS layers that need to be reported to the Commission in 2004, the Guidance Document gives specifications for a short-term centralised option and indicates the way forward for the implementation of a de-centralised system in the long-term. The GIS Working Group underlines that the preference is for the set-up of a de-centralised system in the long-term. The firm implementation of the outlined data model will strongly support this goal.

Since the GIS layers provided by the various River Basin Districts (or countries) will be collated to a European picture, it was further considered to be of importance to agree on a European feature coding system for river basins, water bodies (according to the definition of the WFD), monitoring stations, and pressures. In the long-term, this system should be smart enough to actively support the spatial analysis of pressures and impacts across Europe. The implementation of such a European feature coding system might prove a complicated task, since all Member States have historically implemented their own feature coding systems, adapted to their specific requirements. In view of this situation, the Working Group proposes the short-term implementation of a system that ensures unique feature identifiers across Europe, allowing to maintain national systems and to link them up to the European level. At the same time, the implementation of a feature coding based on the Pfafstetter system is recommended for countries without a dedicated national system. This approach is seen as a first step towards the set-up of a more intelligent European feature coding system, which will need more in-depth study before a definite proposal can be made.

While the WFD as such does not require the introduction of a European feature coding system, the Working Group considered it to be of major importance in the long-term. The main advantage of a European feature coding system would be the possibility for a more targeted analysis of pressures and impacts at the European level and the facilitation of a further integration of water-related monitoring efforts in Europe.

In order to test the feasibility of the distributed structure proposed for the long-term, the working group further implemented a prototype GIS. This prototype is conceived as a testbed for verifying the practical implementation. Examples from this prototype testing phase will be made available on a dedicated web site. Detailed testing of the specifications given in this Guidance Document is further foreseen in the Pilot River Basins, co-ordinated by Working Group 4.1 (Integrated Testing in Pilot River Basins) of the Common Implementation Strategy.

Finally, the Working Group decided not to include specifications for the map making process in this document. This decision is based on the fact that maps will be made at the River Basin District (RBD) level according to the specific needs of each RBD, and at the European level adequate maps can be made from the individual GIS layers. The Working Group, therefore, recommends that in addition to the maps as specified in the WFD, the GIS layers related to these maps should also be transferred to the Commission. The Commission would then have the possibility to make maps out of the GIS layers as required.

In a more general context, it should also be noted that information, consultation and participation are requirements of the Directive, since it will ensure a more efficient and effective implementation. The *Guidance on Public Participation* will tell more about these forms of participation. In particular WFD Article 14 promotes the active participation of all interested parties in the development of River Basin Management Plans and requires Member

States to inform and consult the public. The latter can most efficiently be done through maps, GIS technology and web mapping.

3 Technical Specifications of the GIS

This Section provides detailed specifications for the development of a GIS, compatible with the WFD reporting needs. It outlines the requested GIS layers, the time sequence for reporting and discusses the general aspects of data quality, data geometry and data documentation.

3.1 Timetable for the Preparation and Delivery of Maps and GIS Layers

The following table (Table 3.1.1) indicates when individual maps or GIS layers have to be made available either internally to a River Basin District (⊗) or externally to the Commission (•).

orting Maps

l to GIS	Related Map (App. II)	Year 20..														
		03		04		05	06	07	08	09	10	11	12	13	14	15
ndwaters and coastal waters to			⊗													
mpetent authorities for RBD	2			●												
in rivers and boundaries of the	1			●												
he [surface water body] types tion required under system A	4**				●											
d under art.5 (*)						●[1]										
d under art.8 (*)								●[2]								
lans:										●						
of surface water bodies	3				⊗					●*						
ater body types	4**				⊗					●*						
of groundwater bodies	5				⊗					●*						
areas (location and description ave been designated)	11				⊗					●						
networks	6						⊗			●						
network	10						⊗			●						
programmes for protected areas	12									●						
strating the classification of the rface water	7									●						

l to GIS	Related Map (App. II)	Year 20..												
		03	04	05	06	07	08	09	10	11	12	13	14	15
strating the classification of the surface water	7							●						
trating chemical status for each	8							●						
us	9							●						
	9							●						
f the characteristics and of the on the status of surface waters n district												⊗		
management plans														●
ring results for the period of the														●

hether the "summary report", which has to be delivered in 2005 should contain maps. The Expert Advisory Forum stion. If it is decided that the summary report needs to contain maps, then maps No. 3 and 5 need to be delivered in needs to be delivered both in 2004 and 2009.

2004 according to article 5 and annex II-vi, and in 2009 according to article 13 and annex VII-1.1.

3.2 Overview on the GIS Layers, their Scale and Positional Accuracy

The technical specification of the GIS-layers needed for WFD reporting obligations is based on a detailed analysis of the content of the Water Framework Directive and as far as possible on the documents of the other working groups under the Common Implementation Strategy. All of the maps presented here are explicitly mentioned in the WFD. These maps are translated to GIS-layers, which make up the content of the map. Working with GIS-layers effectively supports the reporting obligations of the Member States and the Commission's needs to access and internally report the information. With the GIS-layers described below and the applied data model, all the requested maps can be made.

The relation between the required maps and the layers is presented in appendix II. GIS-layers are assigned to maps based on the strongest relation. For example, the layer 'River Basin District' is assigned to the map 'River Basin District - Overview'. Some layers can also be part of other maps, which is also indicated. Besides the background layers used for readability of the maps, 15 layers are necessary to make the 12 required maps. Table 3.2.1 presents a summarised view of the maps and layers.

Data collection and map making are the responsibility of the River Basin Districts and the Member States. It is recognised that for data collection an input scale of 1:250,000 or better should be a common goal in the long term. The reporting scale of the maps, however, may either be 1:250,000 or 1:1,000,000 in the short term and should be 1:250,000 in the long term. Only the very general maps No.1 (*River Basin Districts Overview*) and No.2 (*Competent Authorities*) might be reported at smaller scales of up to 1:4,000,000.

To describe the specifications, the GIS-layers are divided in three main groups:

1. Basic information and characteristics of the river basin district;
2. Monitoring network;
3. Status information of surface- and groundwater bodies and protected areas.

The requirements in terms of positional accuracy and input scale and output scale are further described in Section 3.2.4. All the required GIS datasets are vector or point datasets.

Special attention should be given in case of transboundary harmonisation of GIS datasets. In this context, the possibility to use as far as possible already harmonised data is recognised. This is especially true for the case of large international river basins (e.g. the Rhine or the Danube river basin), where the harmonisation work could be substantial. An example of such a database could be EuroGlobalMap at a scale of 1:1,000,000, which is currently under development. For the short-term reporting, this EU-wide database could be an option. In the long term, the scale of reporting may be 1:250,000, as far as an identical and harmonised database (e.g., EuroRegionalMap) is available.

Table 3.2.1: Summary of Maps and GIS –Layers (continued on next page)

Map Name	Layer Code	Layer Name	Feature Type	Availability and Reporting Dates[1]
1: RBD-Overview				
	SW1	River basin district (RBD)	polygon	12/2003 (RBD) 06/2004 (CEC)
	SW2	River basin, sub-basin	polygon	
	SW3	Main Rivers[2]	line	
2: Competent Authorities				
	D7	District of competent authorities	polygon	12/2003 (RBD) 06/2004 (CEC)
3: Surface Water Bodies (SWB) – categories -				
	SW4	Surface water bodies - Rivers - Lakes - Transitional waters - Coastal waters if applicable, indicated as artificial SWB or heavily modified SWB	 line polygon polygon polygon	12/2004 (RBD) 12/2009 (CEC)*
4: Surface Water Bodies (SWB) – types -				
	SW4a	Types of Surface Water bodies	attribute of SW4	12/2004 (RBD) 12/2004 (CEC)* 12/2009 (CEC)*
	D6	Ecoregions	polygon	
5: Groundwater Bodies				
	GW1	Bodies of groundwater	polygon	12/2004 (RBD) 12/2009 (CEC)*
6: Monitoring Network for Surface Water Bodies				
	SW5a	Operational monitoring sites. Inclusive monitoring sites for habitat and species protected areas	point	12/2006 (RBD) 12/2009 (CEC)
	SW5b	Surveillance monitoring sites	point	
	SW5c	Monitoring sites drinking water abstraction points from surface water	point	
	SW5d	Investigative monitoring sites	point	
	SW5e	Reference monitoring sites	point	

(1) RBD: The date when the map or layer needs to be available within the River Basin District.
CEC: The date when the maps need to be reported to the European Commission. Note: The date of December 2009 is the publication date of the River Basin Management Plans. They should be reported to the Commission within 3 months of their publication.
(2) Main Rivers: selection of the rivers from the Water Bodies Layer of map No. 3.
(*) Date of reporting for maps No. 3 and 5 might change to 2004. See also the time schedule in Section 3.1. Map no. 4 needs to be reported in 2004 and 2009 (see also Table 3.1.1)

Table 3.2.1: Summary of Maps and GIS –Layers (continued)

Map Name	Layer Code	Layer Name	Feature Type	Availability and Reporting Dates[1]
7: Ecological Status and Ecological Potential of Surface Water Bodies				
	SW4b	Ecological status	attribute of SW4	12/2009 (RBD) 12/2009 (CEC)
	SW4c	Ecological potential	attribute of SW4	
	SW4d	Bad status or potential causes by (non-) synthetic pollutants	attribute of SW4	
8: Chemical Status of Surface Water Bodies				
	SW4e	Chemical status	attribute of SW4	12/2009 (RBD) 12/2009 (CEC)
9: Groundwater Status				
	GW1a	Quantitative status of groundwater bodies	attribute of GW1	12/2009 (RBD) 12/2009 (CEC)
	GW1b	Chemical status of groundwater bodies	attribute of GW1	
	GW1c	Pollutant trend	attribute of GW1	
10: Groundwater Monitoring Network				
	GW2a	Groundwater level monitoring network	point	12/2006 (RBD) 12/2009 (CEC)
	GW2b	Operational monitoring network chemical	point	
	GW2c	Surveillance monitoring network chemical	point	
11: Protected Areas				
	PA1	Drinking water protection areas	polygon	12/2004 (RBD) 12/2009 (CEC)
	PA2	Economically significant aquatic species protection areas	polygon	
	PA3	Recreational waters	point	
	PA4	Nutrition-sensitive areas	polygon	
	PA5	Habitat protection areas (FFH)	polygon	
	PA6	Bird protection areas	polygon	
12: Status of Protected Areas				
	PA7	Status of protected areas	attribute of PA1-PA6	12/2009 (RBD) 12/2009 (CEC)

(1) RBD: The date when the map or layer needs to be available within the River Basin District.
CEC: The date when the maps need to be reported to the European Commission. Note: The date of December 2009 is the publication date of the River Basin Management Plans. They should be reported to the Commission within 3 months of their publication.

3.2.1 Basic Information

The basic information contains those entities for which the WFD applies. These are the surface water bodies, the groundwater bodies and the protected areas. Furthermore the river basin districts, the river basins and the areas of competent authorities are regarded as basic information.

For the co-ordination of administrative arrangements within river basin districts, and the arrangements within and between Member States, the boundaries of the river basin districts and the competent authorities have to be reported (maps No. 1 and No. 2). The following GIS-layers are required:

- *River basin districts:* The geographical coverage of the river basin district presented as a polygon layer. In cases where the national border is the same as the district border, the national border is leading;
- *River basins and sub-basins:* A polygon layer with the main catchment areas within the river basin district. All the basins and sub-basins taken together fully cover the river basin district. The basins and sub-basins are derived from the hydrological system, whereas the river basin district is designated as the main unit for the management of river basins. While this layer is non-mandatory it provides the basic entities for the river basin management and its delivery is recommended;
- *Main rivers:* A selection from the dataset with surface water bodies, used for general overview purposes;
- *Areas covered by the competent authorities within the river basin district*: A polygon layer with no overlapping features and without uncovered areas and if necessary synchronised with the national border layer and the river basin district layer.

The attributes of these GIS-layers are specified in the description of the data model (see Section 3.3) and in the data dictionary in appendix III.

The environmental objectives of the WFD cover all water bodies as well as areas designated as requiring special protection of their surface and groundwater bodies or for the conservation of habitats and species depending on water. The reporting obligations, therefore, require a general description of the characteristics of the river basin district, including information on surface water bodies, groundwater bodies and all protected areas (maps No. 3, 4, 5, and 11). The requested level of detail of the GIS-layers for surface water bodies and groundwater bodies is based on the essential discussion about the term water body. The outcome of this discussion, presented in the *Horizontal Guidance on the Application of the Term Water Body,* defines which elements should be included in the layer. In the following list we describe the composition of the various layers.

- *Surface Water Bodies*: Surface water bodies are first discriminated into the following categories: rivers, lakes, transitional waters, coastal waters, artificial surface water bodies, and heavily modified surface water bodies. Within each category discrimination is made based on type (according to system A or B). Rivers are represented as line features and lakes, transitional waters or coastal waters as polygons.

- *Groundwater Bodies*: Groundwater bodies are presented as polygon features. The outcome of the Working Group on Groundwater determines the characterisation of the groundwater bodies.

- *Protected Areas falling under specific Community legislation:* they include the following GIS-datasets:

    - Drinking water protection areas (polygons);
    - Economically significant aquatic species protection areas (polygons);
    - Recreational waters (points);
    - Nutrition-sensitive areas (polygons);
    - Habitat protection areas (FFH) (polygons);
    - Bird protection areas (polygons).

Some protected areas may have partially the same geometry as the water bodies, but the main part of the protected areas will have their own geometry. Therefore, the protected areas need to be represented as separate feature layers. The geometric representation of the features is based on the related specific Community legislation.

3.2.2 Monitoring Network

This paragraph deals with the requirements for mapping monitoring stations for reporting and presentation (maps No. 6 and 10). Further information on the requirements for the number of monitoring sites, the size of the related catchment, the sampling frequencies, etc. can be found in the *WFD CIS Guidance Document No. 7 on Monitoring*.

For the purpose of establishing a coherent and comprehensive overview of water status, surveillance monitoring sites will be considered first, since operational monitoring has to be performed in water bodies being at risk of failing to meet the objectives. Modifications of the sites, therefore, are likely.

The monitoring network will serve different purposes according to the water body type:

(i) for surface water:
monitoring the ecological and chemical status and the ecological potential;

(ii) for groundwater:
monitoring the chemical and quantitative status;

(iii) for protected areas:
supplementing those specifications contained in Community legislation under which the individual protected areas have been established;

(iv) for biological reference conditions:
reference conditions can be derived from a spatial network of high status sites (thus more stations per water body may be required);

(v) for drinking water abstraction:
monitoring the chemical and quantitative status.

The location of monitoring points does not statically follow a fixed size of the catchment but depends on sufficient information to assess the overall surface and groundwater status of each catchment, based on knowledge of the environment (region) and on expert judgement. Also stretches of coastal waters, significant international trans-boundary waters and pollutants discharging into the marine environment need to be considered.

The monitoring networks should be delivered in two datasets: one for surface water and one for groundwater. So even if a given monitoring station is used for both surface and groundwater monitoring, it should be considered as two objects. The different kind of monitoring types and purposes are registered in the attributes of the dataset. For surface water these are surveillance monitoring, operational monitoring, and investigative monitoring, or reference sites and sites for drinking water abstraction. For groundwater sites the monitoring types are quantitative monitoring and chemical monitoring. The chemical monitoring sites for groundwaters are further split-up into surveillance and operational sites (see also the data model in Section 3.3). The monitoring network will be presented as point features. The relation between a monitoring station and the represented water bodies is implemented in the data model.

It further needs to be considered that the information on monitoring points (number and location) is dynamic.

3.2.3 Surface Water Bodies, Groundwater Bodies and Protected Areas (Status)

Additionally to what has been mentioned in Section 3.2.2, the maps for status information (maps No. 7, 8, and 9) shall illustrate for a river basin district the classification of the ecological and chemical status of water bodies, colour-coded according to WFD Annex V, 1.4.2. Similarly, this applies to the status of good ecological potential of artificial or heavily modified surface water bodies.

For groundwater bodies or a group of groundwater bodies, both the quantitative and the chemical status shall be shown colour-coded according to the colour scheme given in the WFD Annexes V, 2.2.4 and V, 2.4.5. The status of protected areas shall also be mapped.

The datasets containing the information about the status of the water bodies and protected areas will not be required as separate feature layers but can be delivered as attribute information in tabular format using as a key the unique code of the water body.

3.2.4 Scale and Positional Accuracy

The scale of digital data or, more precisely, the scale of the underlying input data can be regarded as both, an indicator of spatial detail (which level of detail is available for map making), and as an indicator of positional accuracy (what is the possible difference between the true real world co-ordinates and the co-ordinates of the data). The 'spatial detail' determines both the minimum mapping area and the number of co-ordinates used to describe an element. On a large-scale map (i.e. 1:250,000) a river is presented with more points than on a small-scale map (i.e. 1:1,000,000), where, for example, small meanders may not be visible.

While in theory a dataset at 1:1,000,000 scale might contain the same amount of elements (objects) than a dataset at 1:250,000 scale, the latter can present the information in a better way (the positional accuracy is higher and the shapes of the elements are represented with more detail).

The main factor determining the necessary spatial detail of data gathering under the WFD is the size of the smallest feature to be shown on the maps. In the WFD the only direct indication in this context are the size thresholds given for the typology according to system A (WFD Annex II). These thresholds are set to a 0.5 km^2 surface for lakes and to a 10 km^2 catchment area for rivers. Although these thresholds do not imply that all water bodies larger than these numbers need to be reported (see the horizontal guidance on the application of the term "water body"), these figures can be used to estimate the required detail of data gathering or the input scale.

From theoretical considerations of cartography, these thresholds lead to a recommended scale of 1:250,000. On a map with this scale, water bodies with a minimum size of the given thresholds will be clearly visible. A map of 1:1,000,000 scale, to the contrary, will normally not contain lakes with an area of 0.5 km^2 or rivers with a catchment size of 10 km^2. However, digital data with this input scale might contain lakes or rivers of this size, even though they can only be shown as a point or very simple feature.

EuroGlobalMap (EGM) is a dataset that is under development in several Member States. EGM has a scale of 1:1,000,000. As a consequence, not all rivers and lakes larger than the thresholds mentioned above are incorporated in EGM. This implies that, if a Member State wants to use EGM for reporting under the WFD, EGM has to be extended, adding more lakes and rivers. The difference to a 1:250,000 dataset will be that the shape of the objects (rivers, lakes, etc.) will be less detailed or not available at all and that the positional accuracy will be worse. While EGM aims at a positional accuracy of 1000 metres, data layers with an input scale of 1:250,000 generally present objects with a positional accuracy in the order of 125 metres.

Considering both the WFD needs and the practical constraints of data availability, the GIS Working Group recommends that the required positional accuracy for the reporting is set to a minimum of 1000 metres (corresponding to an input scale of approximately 1:1,000,000) in the short-term, while at the same time it is strongly recommended to strive for a positional accuracy of 125 metres (corresponding to an input scale of approximately 1:250,000) in the long-term.

With a minimum requirement of 1000 metres, existing national or European datasets could be used, if amended with the necessary detail. In many cases, problems related to the data policy of such datasets might be less severe than problems related to a stringent requirement of 125 metres of positional accuracy in the short-term. However, in cases where data availability and data policy do not pose a problem, datasets with the highest possible positional accuracy are preferred. In the long-term, these datasets should in any case be the target.

3.2.5 River Basin Management Plans and Summary Reports

Among the various maps, registers, and reports listed as elements of the River Basin Management Plan in Annex VII of the WFD, the following are mentioned:

"*A register of any more detailed programmes and management plans for the river basin district dealing with particular sub-basins, sectors, issues or water types, together with a summary of their results*" (Paragraph 8), and

"*The contact points and procedures for obtaining the background documentation and information referred to in article 14(1), and in particular details of the control measures* *adopted in accordance with Article 11(3)(g) and 11(3)(i) and the actual monitoring data gathered in accordance with article 8 and Annex V*" (Paragraph 11).

These two paragraphs indicate that there is a distinction between "information included in the river basin management plan" (summaries) and more detailed information to be obtained from the national contact point.

In addition, Article 18 of the WFD refers to the Commission's report on progress in the implementation of the WFD based on "summary reports" that Member States submit under Article 15(2).

The above mentioned quotations indicate that a distinction should be made between the rate of detail to be used in reporting to the Commission (small scale) and the rate of detail Member States should have available upon request (large scale).

However, at this moment there is no clear guidance on the level of detail (input scale and spatial accuracy) to be used by Member States in order to fulfil the WFD summary based reporting obligations. This question will be further elaborated in the EAF on Reporting together with the future GIS Working Group.

3.3 Data Model

3.3.1 Purpose of the Data Model

The Water Framework Directive expresses a set of requirements for geographic information. Ultimately, this information will be stored in a number of databases. Data modeling is the first step in database design – it is the blueprint from which the GIS will be built. By modeling, complexity is reduced so that all actors should be able to understand the essence of the system. This provides the basis of development of a common understanding of which objects should feature in the geographic database, and how they should be represented. The model also aims to encourage consistency in data structures to facilitate data sharing.

Key activity 3: Improved Data and Information Management, Project 3.1 – "Development of a Geographical Information System (GIS)" states that "*the data model proposed needs to be defined in such a way that it can accommodate the information resulting from the national obligations of the WFD or that it can be linked to national systems via the coding system*."

3.3.2 The Unified Modelling Language

The Unified Modelling Language (UML) is a modeling notation that provides tools for modeling every aspect of a software system from requirements to implementation.

UML has become a standard methodology, and is increasingly being applied to the modeling and design of Geographic Information Systems and Databases. In line with the position of the INSPIRE Architecture & Standards Working Group, a UML diagrammatic notation is used here to present an overview of the logical model, together with a detailed data dictionary (Appendix III) describing the attributes of the tables that will be created from the model.

Whilst UML can be applied in many aspects of system design, in the context of the WFD GIS Data Model only a restricted subset of static structure diagrams are used.

3.3.3 Data Model Overview

The data model aims to satisfy the requirements, primarily as defined by the Directive itself, but also based on commonly agreed definitions resulting from discussions in the GIS-WG and other Working Groups. Wherever appropriate, relevant definitions from the Directive itself are given.

Within the model, logically related features are grouped together. Thus, the model extends the basic distinctions in the Directive between "Surface Water" and "Groundwater" and "Protected Areas", adding the "Monitoring Network", "Management/Administration" and "Ecological Status".

Wetlands

Wetland ecosystems are ecologically and functionally parts of the water environment, with potentially an important role to play in helping to achieve sustainable river basin management. The Water Framework Directive does not set environmental objectives for wetlands. However, wetlands that are dependent on groundwater bodies, form part of a surface water body, or are Protected Areas, will benefit from WFD obligations to protect and restore the status of water. Relevant definitions are developed in the WFD CIS Guidance Document No. 2 on *Water Bodies* and further considered in the guidance on *Wetlands (under preparation)*.

Pressures on wetlands (for example, physical modification or pollution) can result in impacts on the ecological status of water bodies. Measures to manage such pressures may therefore need to be considered as part of river basin management plans, where they are necessary to meet the environmental objectives of the Directive.

Wetland creation and enhancement can, in appropriate circumstances, offer sustainable, cost-effective and socially acceptable mechanisms for helping to achieve the environmental objectives of the Directive. In particular, wetlands can help to abate pollution impacts, contribute to mitigating the effects of droughts and floods, help to achieve sustainable coastal management and to promote groundwater recharge. The relevance of wetlands within programmes of measures is examined further in a separate horizontal guidance paper on wetlands.

Given the role wetlands can play in achieving the environmental objectives of the WFD, it is recognised that it would be important to identify and include wetlands as objects in the GIS, including their key attributes. Wetlands will be related to groundwaters, surface waters and protected areas. As soon as relevant information on the definition and attributes of wetlands are available, the data model should, therefore, be extended accordingly.

The following three figures (Figures 3.3.1 to 3.3.3) show the core components of the model – Water Bodies, Monitoring Stations, Administration and Status:

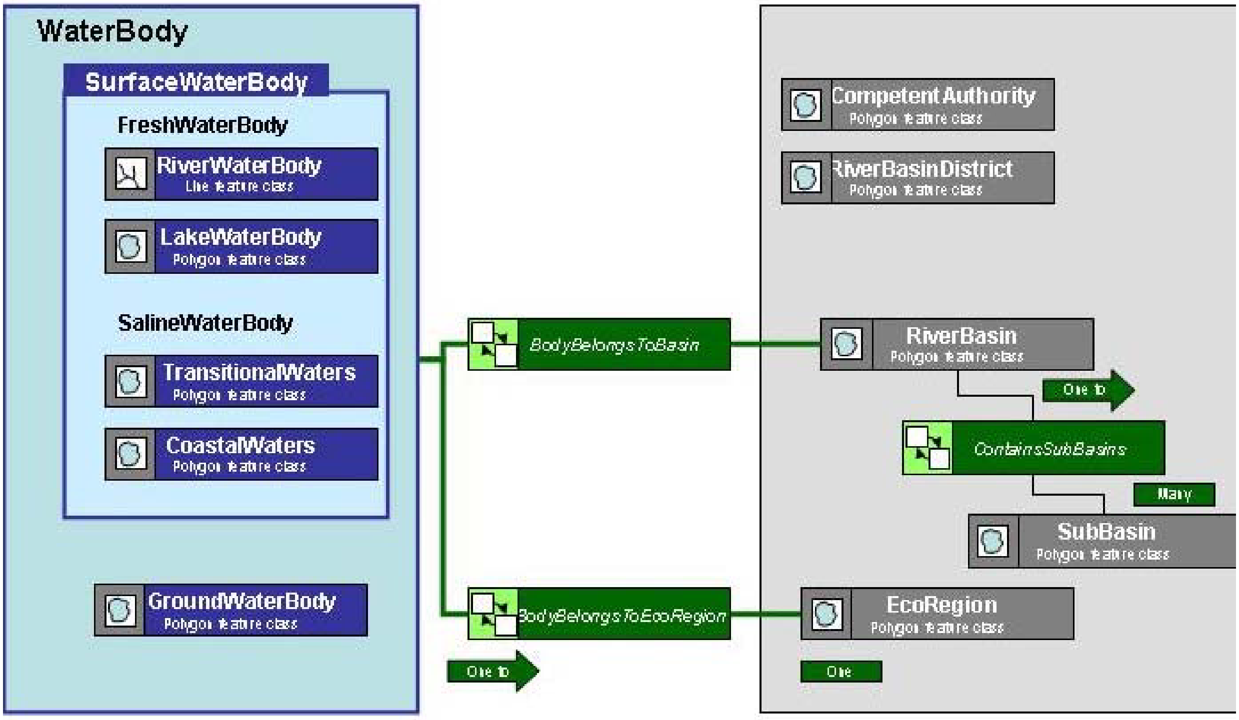


Figure 3.3.1: Water Bodies and Management Units.

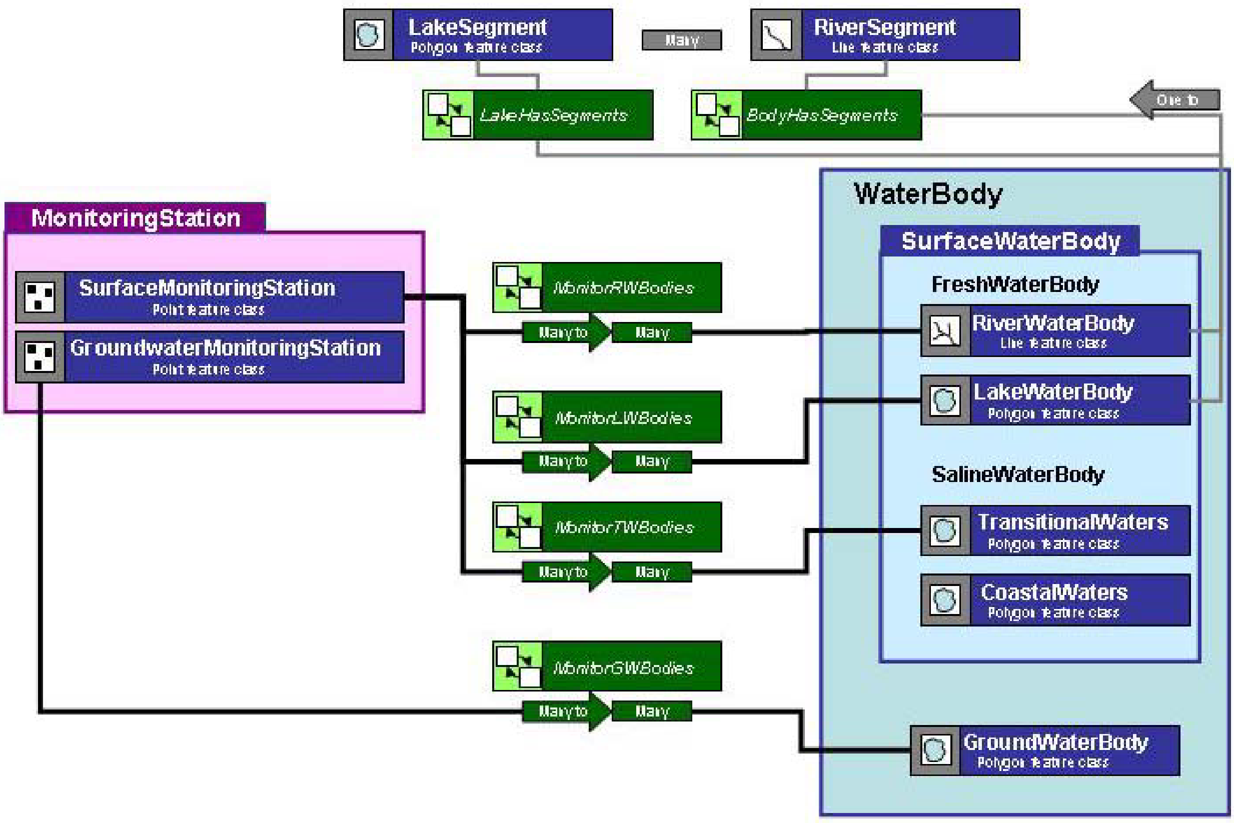


Figure 3.3.2: Water Bodies and Monitoring.

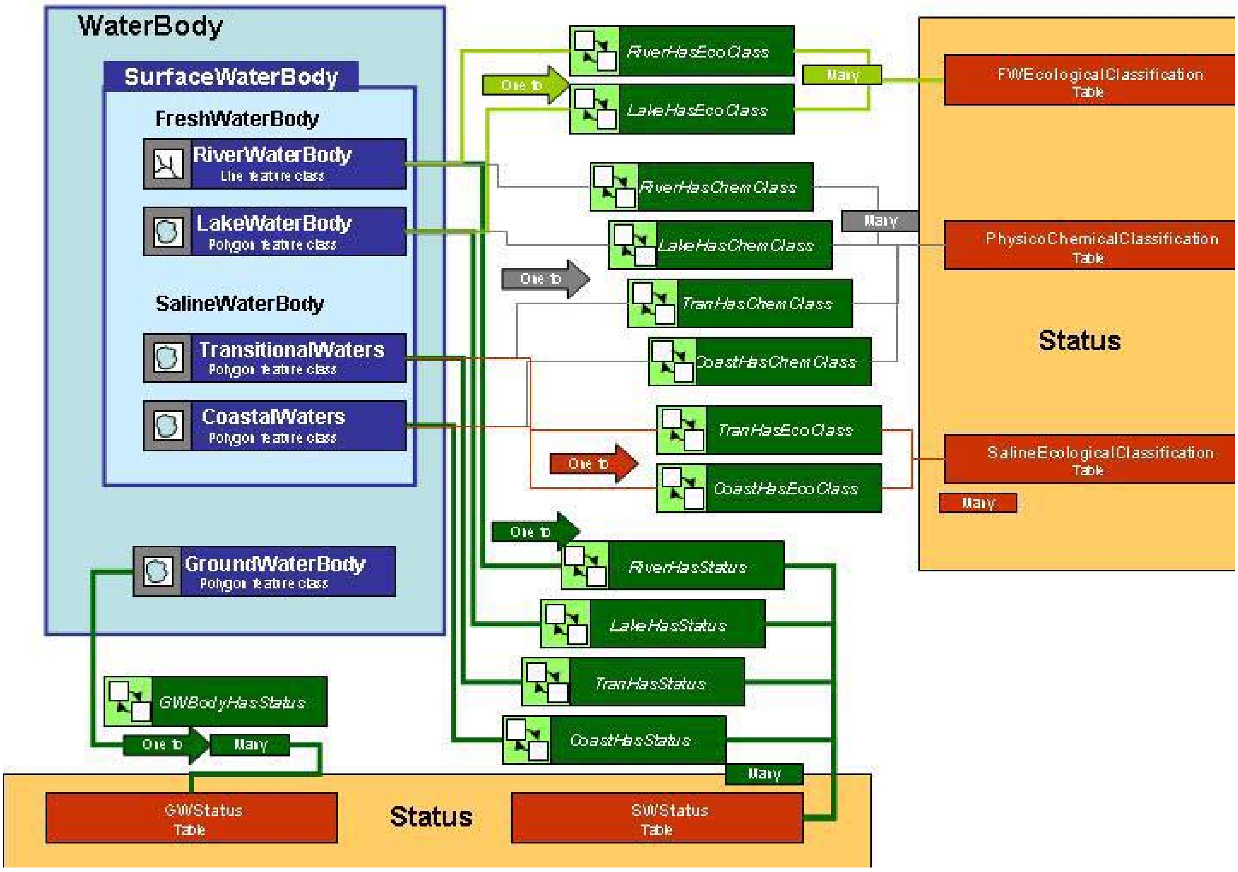


Figure 3.3.3: Water Bodies and Status.

Geometric Representation

In the simple approach presented here, features are represented as simple features only (i.e. points, lines, or polygons). Optionally, the same set of real world features could be modeled as a simple or complex network. Since the main objective of the Directive is reporting, not analysis, this may not be a priority, but should not be excluded at this stage and is discussed further below.

Linear measuring systems are in use in some, but not all, Member States. Instead of explicit x,y locations, data are recorded with reference to relative positions according to a known feature. For example, river segment 2800, kilometer 23.1 identifies a position in geographic space without the use of x,y co-ordinates. Because such measurements refer to relative positions, they can be updated easily without having to edit the underlying geometry of the river network.

Whilst this may become a standard approach in the future, the current release of the model provides a simple feature based approach. Thus, in the case of river lines, any status categorization (for example, poor quality symbolized in red) will apply to the entire line feature, from node to node. The identification and representativity of the segments is therefore crucial, and presents problems if the status values are dynamic. Given that reporting is on a six yearly basis, this problem is not significant. Clearly it is the Member States responsibility therefore to define water bodies, and their segmentation into individual features, according to the following principles:

> To enable "water bodies" to act as **compliance checking units**, their identification and subsequent classification must provide for the accurate description of the status of the water environment.
>
> The Directive only requires sub-divisions of surface water and groundwater that are necessary for the clear, consistent and effective application of its objectives. Sub-divisions of surface water and groundwater into smaller and smaller water bodies that do not support this purpose should be avoided.
>
> A "water body" must be capable of being assigned to a single ecological status class… (source "*WFD CIS Guidance Document No.2 on "Water Bodies"*"").

The option of using linear referencing merits further discussion as to the feasibility and desirability of such an approach.

3.3.4 Feature Classes

Feature classes, i.e. those classes in the model which contain explicit geometry, and are thus point, line or polygon features, are as follows. All these classes inherit from the class feature, in that they have geometry and will have a unique internal identifier in the database. Feature classes cannot mix geometry types – they must be exclusively points, or lines, or polygons.

Feature
- SubBasin
- RiverBasin
- RiverBasinDistrict
- CompetentAuthority

Feature *MonitoringStation*
- SurfaceMonitoringStation
- GroundwaterMonitoringStation

Feature *WaterBody*
- GroundwaterBody
- *SurfaceWaterBody*
  - *FreshWaterBody*
    - RiverWaterBody
      - RiverSegment
    - LakeWaterBody
      - LakeSegment
  - *SalineWaterBody*
    - TransitionalWaters
    - CoastalWaters

Feature
- ProtectedArea

Feature
- EcoRegion

Inheritance allows classes to be related to parents through generalization. The more specific class inherits attributes from the more general class.

In practical terms, every UML class becomes a table. Every UML attribute in a class becomes a column in a table. Appendix III (Data Dictionary) provides a physical description of the tables and columns, which complements the discussion of each of the classes which follows.

3.3.4.1 General

EcoRegion

Polygon features, with a Name and a unique EcoRegionCode. Two systems are defined according to WFD Annex XI –A for rivers and lakes, and WFD Annex XI – B for transitional waters and coastal waters.

WaterBody

All surface water (SW) and groundwater (GW) bodies inherit from the WaterBody abstract class, which defines the following attributes:

- **EuropeanCode**. A unique identifier at European level, including the 2 character ISO Country Code;
- **Name;**
- **MSCode**. The unique code for the water body defined in the Member State;
- **EcoRegionCode.** The relationship between a water body and its parent EcoRegion is via the EcoRegionCode;
- **InsertedWhen;**
- **InsertedBy;**
- **RiverBasinCode.** The relationship between a water body and its parent RiverBasin is via the EcoRegionCode;
- **StatusYear.**

3.3.4.2 Surface Water

From the Directive definitions, "*Surface Water means inland waters, except groundwater; transitional waters and coastal waters, except in respect of chemical status for which it shall also include territorial waters*."

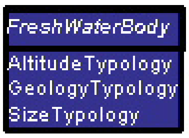
Thus the abstract class SurfaceWaterBody is classified into FreshWater and SalineWater, according to the different sets of attributes.

SurfaceWaterBody

A SurfaceWaterBody abstract feature class defines the following attributes:

- **HeavilyModified** True/False. Heavily modified water body means a body of surface water which as a result of physical alterations by human activity is substantially changed in character, as designated by the Member State in accordance with the provisions of Annex II;
- **Artificial** True/False. Artificial water body means a body of surface water created by human activity;
- **System**. Whether the water body is Type A or Type B.

FreshWaterBody



The abstract feature class FreshWaterBody inherits from the SurfaceWaterBody class, and defines the following additional attributes:

- **AltitudeTypology**. Whether the body is in a high, mid-altitude or lowland area;
- **GeologyTypology**. Basic geological type of the area;
- **SizeTypology**. Size categories will differ between rivers and lakes.

SalineWaterBody

The abstract class SalineWaterBody inherits from SurfaceWaterBody and defines the following additional attribute:

- **SalinityTypology**. Based on the mean annual salinity.

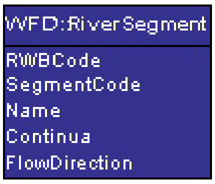
RiverWaterBody

RiverWaterBody means a body of inland water flowing for the most part on the surface of the land but which may flow underground for part of its course. The term RiverWaterBody is used to correspond with the WFD CID Guidance Document No. 2 on Water Bodies, where it is indicated that a single water body may consist of several component river segments. A RiverWaterBody is not therefore required to be a feature class, instead it is a list of the RiverSegment features which make it up. The RiverWaterBody class inherits from the FreshWaterBody abstract class. For the remaining attributes, which are to be completed in the case of a Type B River, the Directive does not give any indication of their definition or allowable values.

A RiverWaterBody is related to its component RiverSegments through the one-to-many relationship *BodyHasSegments*.

RiverSegment

The Directive does not explicitly state how to identify individual stretches of river (i.e. the concept of river reaches). It defines rivers, as other surface water bodies, as "*a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal*". As a minimum requirement, river segments should be defined between confluences, and will probably be split additionally at point locations in the Monitoring Network. This is in line with the Horizontal Guidance on water bodies. In this model, river segments are simple line features with nodes at the endpoints.



- **RWBCode** The unique code of the RiverWaterBody to which the segment belongs.
- **SegmentCode** The unique code of the RiverSegment.
- **Name** The locally applicable name for the RiverSegment.
- **Continua** Whether the river segment is a true river reach, or an imaginary *continua* created in order to maintain network connectivity. *Continua* are, for example, imaginary stretches of a river under a lake.
- **FlowDirection** Whether or not the flow direction along the segment is the same as the direction in which it was digitized.

LakeWaterBody

According to the Directive, "*Lake means a body of standing inland surface water*". Lakes are termed as LakeWaterBody in the model to allow for the subdivision of individual lakes into distinct bodies. A LakeWaterBody is not therefore a feature class in itself – it is rather a list of the individual LakeSegments (polygons) which make it up. The LakeWaterBody class inherits from the abstract class FreshWaterBody and defines the following additional attributes:

- **DepthTypology**. Based on the mean depth of the lake.

For the remaining attributes, which are to be completed in the case of a Type B LakeWaterBody, the Directive does not give any indication of their definition or allowable values.

A LakeWaterBody is related to its component LakeSegments through the one-to-many relationship *LakeHasSegments*.

LakeSegment

A LakeWaterBody is composed of one-to-many LakeSegments. A LakeSegment shall be an area (polygon) feature, and should have nodes at inlets and outlets, thus providing connectivity to the RiverSegment (line) features and to any internal "*continua*" segments defined.

- **LWBCode** The unique code of the LakeWaterBody to which the segment belongs;
- **SegmentCode** The unique code of the LakeSegment;
- **Name** The locally applicable name for the LakeSegment.

TransitionalWaters

Transitional waters are "*bodies of surface water in the vicinity of river mouths which are partly saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flows*".

The TransitionalWaters feature class inherits from the abstract class SalineWaterBody and defines the following additional attributes:

- **TidalTypology.** Based on the mean tidal range.

Transitional waters will typically be estuaries, and modeled as polygon features. The use of river segments (as lines), to reach as far as coastal outlets, will maintain the network connectivity (see Coding Systems).

For the remaining attributes, which are to be completed in the case of Type B TransitionalWaters, the Directive does not give any indication of their definition or allowable values.

CoastalWaters

Coastal water means "*surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters*".

The CoastalWaters feature class inherits from the abstract class SalineWaterBody, and defines the following additional attributes:

- **DepthTypology** Based on the mean depth.

For the remaining attributes, which are to be completed in the case of Type B CoastalWaters, the Directive does not give any indication of their definition or allowable values.

For the feature classes which inherit from the abstract class SurfaceWaterBody, a number of attributes are in common (e.g. MeanSubstratComp). In the model these are not passed to the parent class simply to clarify the distinction between Type A and Type B categorization (e.g., the attribute SalinityTypology is a minimum requirement for Type A, both for TransitionalWaters and CoastalWaters, and is therefore presented as an attribute of the SalineWaterBody class. WaveExposure is an example of an optional Type B attribute, and is therefore presented at the feature class level).

3.3.4.3 Groundwater

GroundwaterBody

The GroundwaterBody feature class inherits from the WaterBody abstract class. Body of groundwater means "*a distinct volume of groundwater within an aquifer or aquifers*".

The Directive does not provide standard criteria for the characterization of groundwater bodies, although Member States should provide information on pressures, overlying strata and dependent surface water and terrestrial ecosystems. For groundwater bodies considered to be at risk, further detail on these geological and hydrogeological characteristics can be provided. Information concerning the impact of human activity may also be collected.

The model does not deal with these parameters, but this might be an area that merits increased standardization of the information gathered.

Discussion continues on how such bodies should be delineated, and subsequently represented. For the purposes of the present model, it is assumed that groundwater bodies will be 2-dimensional (i.e. planar) polygon features. Unlike surface water bodies, the delineated boundaries of groundwater will rarely coincide exactly with river basins. Thus the Directive requirement that groundwater bodies must be assigned to a River Basin District will have to be achieved through a relationship in the database, which should be the approach for all water bodies.

The GroundwaterBody feature class defines the following attributes:

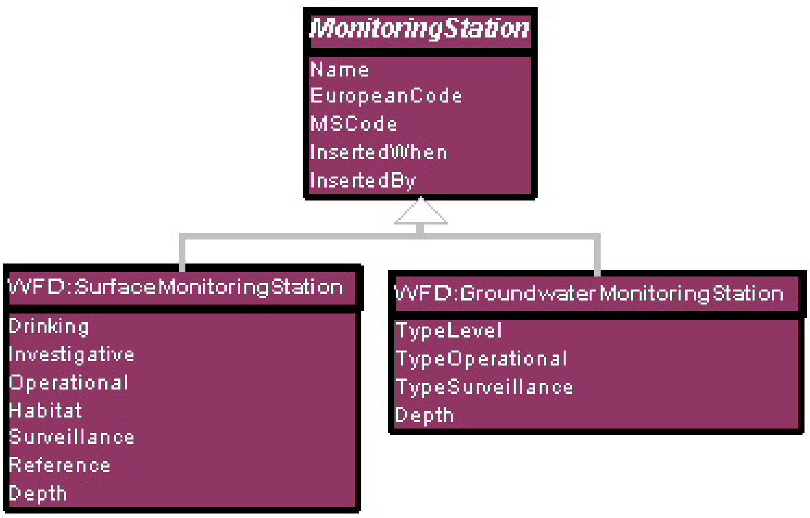
- **Horizon** – For groundwater bodies, reported separately but which are overlying, the horizon attribute provides a distinction of the individual strata.

3.3.4.4 Monitoring Network

Monitoring Stations shall form the basis of the monitoring of water status. The Directive distinguishes between Surface Water Monitoring and Groundwater Monitoring. The monitoring is the basis for subsequent classification of water bodies, but it is not a requirement from a GIS perspective to access the underlying data used to arrive at these status characterizations. Annex V, Article 1.3 states that "*Member States shall provide a map or maps showing the surface water monitoring network in the river basin management plan*". Similarly, Article 2.2.1 states that the groundwater monitoring network shall also be provided as a map or maps.

Thus the model defines an abstract class "MonitoringStation", further subdivided into SurfaceMonitoringStation and GroundwaterMonitoringStation.

MonitoringStation



The abstract class "MonitoringStation" defines the following additional attributes:

- **Name**. If appropriate, a name can be provided for the station;
- **EuropeanCode** A unique code, incorporating the ISO Country Code plus the MSCode below;
- **MSCode** A unique code for the monitoring station.

Monitoring stations are point features. They are further categorised into SurfaceMonitoringStations and GroundwaterMonitoringStations. Since a station may serve multiple functions, it is not appropriate to define distinct subtypes (e.g. a Groundwater station may perform any or all of the functions level (quantity), operational and surveillance monitoring).

The feature class **SurfaceMonitoringStation** inherits from the abstract class MonitoringStation, and defines the following additional attributes to identify the functions it performs:

- **Drinking –** Y/N if the station is a drinking water abstraction;
- **Investigative –** Y/N if the station is an investigative station;
- **Operational –** Y/N if the station is an operational station;
- **Habitat –** Y/N if the station is a habitat monitoring station;
- **Surveillance –** Y/N if the station is a surveillance station;
- **Reference –** Y/N if the station is a reference station;
- **Depth** – Depth in metres.

The feature class **GroundwaterMonitoringStation** inherits from the abstract class MonitoringStation, and defines the following additional attributes to identify the functions it performs:

- **TypeLevel**– Y/N if the station is an operational station;
- **TypeOperational**– Y/N if the station is an operational station;
- **TypeSurveillance**– Y/N if the station is a surveillance station;
- **Depth –** Depth in metres.

Monitoring stations may have multiple functions, as described above, and also may monitor multiple water bodies. They therefore have a many-to-many relationship with WaterBodies, as follows:

The feature class SurfaceMonitoringStation participates in the many-to-many relationships MonitorRWBodies, MonitorLWBodies and MonitorTWBodies.

The feature class GroundwaterMonitoringStation participates in the many-to-many relationship MonitorGWBodies.

3.3.4.5 Status

For each SurfaceWaterBody, ecological and chemical status categories are reported. However, a further level of detail is possible, in which individual ecological, hydromorphological and chemical quality parameters are recorded (Annex V, Article 1.2).

Again, a distinction can be made between Fresh and Saline waters. For each of these elements reported, the StatusDate is recorded.

Status parameters are also reported for groundwater bodies, again with a StatusDate allowing multiple status reports to be made for the same body over time.

All status parameters are linked to the relevant water body via the unique EuropeanCode.

GWStatus

The GWStatus class provides status reports for a given date for a given Groundwater Body, identified by the EuropeanCode. In addition, the following specific quality attributes are defined (see Data Dictionary Appendix III for allowable values):

- **QuantitativeStatus**. For good status, the level of groundwater in the groundwater body is such that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction;
- **ChemicalStatus**. The chemical composition of the groundwater body as determined by pollution concentrations;
- **PollutantTrend**. The long-term trend in anthropogenically induced pollutants;
- **ConfidenceLevel**. The level of confidence associated with the PollutantTrend assessment above (Annex V, Article 2.4.4).

SWStatus

The SWStatus class provides status reports for a given date for a given surface water body, identified by the EuropeanCode. In addition, the following specific quality attributes are defined (see Data Dictionary Appendix III for allowable values):

- **EcologicalStatus**. Ecological status is an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V;
- **EcologicalPotential** (for Heavily Modified or Artificial bodies) according to the categories in the *QualityClassification* domain;
- **NonCompliant**. True/False. For those bodies which may be at risk of failing to meet quality objectives;
- **ChemicalStatus** is either Good, or FailingToAchieveGood (Annex V, 1.4.3). Good surface water chemical status means the chemical status required to meet the environmental objectives for surface waters established in Article 4(1)(a), that is the chemical status achieved by a body of surface water in which concentrations of pollutants do not exceed the environmental quality standards established in Annex IX and under Article 16(7), and under other relevant Community legislation setting environmental quality standards at Community level.

FreshwaterEcologicalStatus

The FWEcologicalClassification class is related to a particular water body by the EuropeanCode. This class defines the following attributes (Annex V, Article 1.2.1, 1.2.2):

- **Phytoplankton;**

- **Macrophyto**. Macrophytes and Phytobenthos;
- **BenthicInvertebrates;**
- **Fish;**
- **HydrologicalRegime;**
- **RiverContinuity;**
- **MorphologicalConditions.**

PhysicoChemicalClassification

The PhysicoChemicalClassification class is related to a particular water body by the EuropeanCode. This class applies to all surface water body types, and defines the following attributes (Annex V, Article 1.2.1, 1.2.2):

- **GeneralConditions;**
- **SyntheticPollutants;**
- **NonSyntheticPollutants**.

3.3.4.6 SalineWater Ecological Status

For Transitional and Coastal Waters, the SalineEcologicalClassification class defines the following attributes:

- **Phytoplankton;**
- **Macroalgae**. Merged with angiosperms for coastal waters;
- **Angiosperms**. Merged with angiosperms for coastal waters;
- **Benthicinvertebrates;**
- **Fish;**
- **TidalRegime**. According to the QualityClassification domain;
- **MorphologicalConditions**. According to the QualityClassification domain.

3.3.4.7 Management / Administration

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 unit for management of river basins.

A WaterBody or a MonitoringStation may belong to a single RiverBasinDistrict (even if this may not physically be the case – ref. CIS-WFD Project 2.9 “Guidance on Best Practices in River Basin Management Planning”).

SubBasin

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).*”

The SubBasin feature class defines the following attributes:

- **Name;**
- **RiverBasinID**. The relationship between a SubBasin and its parent RiverBasin is via the RiverBasinID;
- **SubBasinID**. Each SubBasin shall have a unique code, which should link to the coding used for the river network.

The SubBasin feature class shall be defined as polygons.

RiverBasin

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.*" RiverBasins shall be assigned "*to individual river basin districts"*.

The RiverBasin feature class defines the following attributes:

- **Name;**
- **MSCode;**
- **EuropeanCode;**
- **DistrictCode**. The relationship between a RiverBasin and its parent RiverBasinDistrict is via the DistrictCode;
- **AreaKM2.** Reported area in square kilometres.

The RiverBasin feature class shall be defined as polygons.

An important geometric rule is that river basins shall not overlap.

RiverBasinDistrict

RiverBasinDistricts can be collections of RiverBasins, TransitionalWaters and CoastalWaters. Thus, despite duplication of some geometry, they are defined as a separate polygon feature class. In addition, the following attributes are defined:

- **Name;**
- **MSCode;**
- **EuropeanCode;**
- **CompetentAuth**. The code of the parent Competent Authority.

CompetentAuthority

Competent Authority means an authority or authorities identified under Article 3(2) or 3(3). Because in some cases it is not possible to aggregate RiverBasinDistricts to form the boundary of the CompetentAuthority, they are defined as a separate polygon feature class.

- **Name;**
- **Address;**
- **AuthorityCode.**

3.3.4.8 ProtectedAreas

Annex V of the WFD states that the river basin management plan "*shall include maps indicating the location of each protected area and a description of the Community, national or local legislation under which they have been designated*".

No further specifications are provided by the Directive which might assist data modeling. Activities related to the other Directives and legislation concerning these protected areas may result in further specifications. However, at the present time ProtectedAreas are modeled as simple geometric features, each with a name and, where appropriate, a unique European Code allowing them to be distinctly identified. Whilst certain protected areas may currently be reported as point locations, it is strongly recommended that they are reported as polygon features whenever possible.

ProtectedArea

The feature class ProtectedArea defines the following subtypes:

- **DrinkingWaterProtection;**
- **RecreationalWater;**
- **EconomicSpeciesProtection;**
- **NutrientSensitiveArea;**
- **HabitatProtection;**
- **BirdProtection.**

Each subtype shares the same attributes:

- **Name;**
- **EuropeanCode.**

3.4 European GIS Feature Coding

3.4.1 Introduction

GIS feature coding is the assignment of unique identification codes to each spatial feature that will be referenced by GIS. This assignment needs to be managed to ensure uniqueness at national and international levels. Standard code formats will ease electronic data transfer and enhance the possibility of central querying against distributed storage.

3.4.2 Unique European codes

Unique European codes are provided by the following format

MS$\#_1\#_2\ldots\#_{22}$ where:

MS = a 2 character Member State identifier,
in accordance with ISO 3166-1-Alpha-2 country codes, and

$\#_1\#_2\ldots\#_{22}$ = an up to 22 character feature code that is unique within the Member State.

For example:-
a *Groundwater Body in Germany* might have the identifier DE45734
or a *Lake Monitoring Station in Spain* might have the identifier ES67003800958730

Special advice given is that:

- Alphabetical characters should always be in upper case, as systems will be case sensitive;
- Special characters must be avoided, such as '$', '!', '&', 'ë', 'á', etc.;
- Digits should be used where practical to help avoid the above problems.

Use of the MS$\#_1\#_2\ldots\#_{22}$ is the only requirement for unique European feature identification codes. The Data Dictionary in Appendix III allows for these identification codes. Codes of this format should be used for initial and subsequent references to features when reporting to the Commission.

3.4.3 Managing Codes *within* Member States and RBDs

The above mentioned up to 22 alphanumeric string, $\#_1\#_2\ldots\#_{22}$, should be as short as possible to avoid keying mistakes, yet as long as is required to support unique code maintenance at local operational levels. Precise structures are a matter for each Member State to decide upon. However, some guidance is provided here to establish principles that may be adopted to assist code management within Member States.

3.4.3.1 Unique Identification of Coding Authorities

Some features will be identified on a one off basis, by a single agency acting at a national level. Others may be frequently established and identified by multiple organisations. In the latter case, a structured approach can ease the assignment of identifiers locally while automatically forming unique European identification codes. Examples are provided here in order to clarify this point.

There may be a number of authorities, such as counties, regions or Länders, responsible for the establishment of monitoring stations. Each may have sub-authorities such as urban district councils with similar responsibilities. In such a case, it is useful if coding authorities are first assigned unique identifiers at Member State level. For example the initial two digits of a four digit authority code 'AAAA' might be used, e.g., '**40**00', '**17**00' or '**23**00'. The last two digits might be used to identify sub-authorities or regional offices. For example '17**10**', '17**14**', etc. These authorities can then easily generate locally unique codes. A local code becomes nationally unique by the addition of the AAAA code as a header, and internationally unique by the further addition of the MS code. For example, if a monitoring station is locally given the unique identifier of '12345' by coding authority 1700 in Denmark, then that station would be uniquely identified as DK170012345 when reporting to Europe.

This approach is strongly recommended where multiple agencies are, or will be, involved in the ongoing identification of features. Exact coding structures to be used will be a matter for individual Member States to decide upon and these are likely to vary by feature type.

3.4.3.2 Unique Identification Coding at Operational Levels

The above technique can be taken further within coding authorities, where appropriate. For example, if drinking water abstraction monitoring is managed at drinking water scheme level, then a coding authority may first assign unique identifiers to drinking water schemes. The scheme managers can then easily assign unique identifiers to monitoring stations at a local level.

3.4.3.3 Using the River Network for Unique Code Assignments

Once the river network has been uniquely coded, it can be used to assign unique codes to features that are connected to it. This provides another mechanism for assignment of unique codes at a local level without having to cross check against national assignments.

River segment identification codes can be used locally to assign unique codes to:

- river water bodies;
- lakes;
- lake water bodies;
- transitional water bodies; and
- the monitoring stations for all of these.

As explained later, the outlet river segment code should generally be used for hydrologically connected features that are associated with multiple river segments.

For example, monitoring stations can be identified with codes that are an extension of river codes. The first two digits of a 4-digit monitoring station code 'MMMM' might be used. The last two digits could be used at a later stage to allow further stations to be inserted, while maintaining a sequence to the order of stations. Such a sequence would be important for the purpose of visual confirmation of uniqueness.

Thus, for example, if a river segment has 3 monitoring stations, these might be identified as '0100', '0200'and '0300' as we move upstream. If at a later date we want a station between the first and second, then it would have a station code of '0150'. If the river water body code was 'IE54321', then the full unique monitoring station code would be 'IE543210150'.

Practiced variations on this approach include the use of upstream distance. This has the benefit of providing exact location. It has the disadvantage of requiring prior distance analyses and GIS can maintain location in any regard. Again, this is a matter for individual Member States to decide upon and is very dependent of the capabilities and structures of code management organisations.

3.4.3.4 Monitoring Stations

As described above, monitoring stations may be uniquely identified by extending identification codes for river segments or coding authorities. It is very important that monitoring stations retain their initial identification codes regardless of subsequent changes in river water bodies and coding authorities. If monitoring stations were re-coded to reflect such changes, then the link to historic data relating to these stations would be lost.

The extension of feature and coding authority codes provides a mechanism for data validation. This is an added bonus gained from such code extensions. If such validation is used, the database will need to allow relaxation where the monitored features or coding authorities have changed.

However, it must be remembered that the primary purpose for such code extensions is not data validation; it is to help with the management of unique code assignment at local levels.

3.4.4 Structured Hydrological Unique River Identifiers

3.4.4.1 Coding Approach

If rivers are already substantially identified, it may be pragmatic to extend existing coding. However, the number of rivers to be identified may amount to multiples of the number already coded. Codes may also need to be reviewed to achieve harmonisation with Member States involved in shared RBDs. Coding could be as simple as sequential identifiers; however, structured hydrological codes are recommended. This enables rapid manual or automated analyses without the need to refer to GIS. Hierarchical structured coding also tends to ease long-term unique code maintenance.

Many existing river coding systems are reviewed in a document to be found at http://193.178.1.168/River_Coding_Review.htm. The Pfafstetter system is the generally preferred system. Its benefits are addressed at the above web address. Pfafstetter implementation issues are addressed in Appendix IV. However, it is felt that further consideration is required in order to produce a system that adequately caters for rivers, lakes and marine waters in an integrated way.

In the mean time, structured hydrological codes are preferable to random or non-hydrological codes. And thus, where extensive further river coding is expected, a modified version of the Pfafstetter system is proposed as an interim solution pending the possible adoption of a further modified or alternative system.

3.4.4.2 The (Interim) Modified Pfafstetter System

The code takes the form

MS MW N_1 N_2 N_3 N_4, ….

MS = Member State responsible for code assignment (outlet state for cross-border river segments). Use a 2-character Member State identifier, in accordance with ISO 3166-1-Alpha-2 country codes.

MW = Marine Waters identifier. (In accordance with the International Hydrographic Organisation delineation[1], with possible further local sub-divisions per regional marine agreements).

N_1 N_2, .. = Pfafstetter code[2]. This is a series of 1 digit nested codes. These codes are generated by the following process (see Figures 3.4.1 – 3.4.4)

Moving from river exit to source, the 4 most significant rivers are identified and assigned consecutive even numbers (e.g. 2, 4, 6 and 8.). The use of '0' is reserved for closed basins, i.e. with no outlet.

Each significant river has its own catchment. The remaining areas of the overall catchment are the inter-catchments. These are numbered using consecutive odd numbers, starting with '1' being the inter-catchment between the sea and the first significant tributary and ending with '9', being the headwaters or upper catchment area.

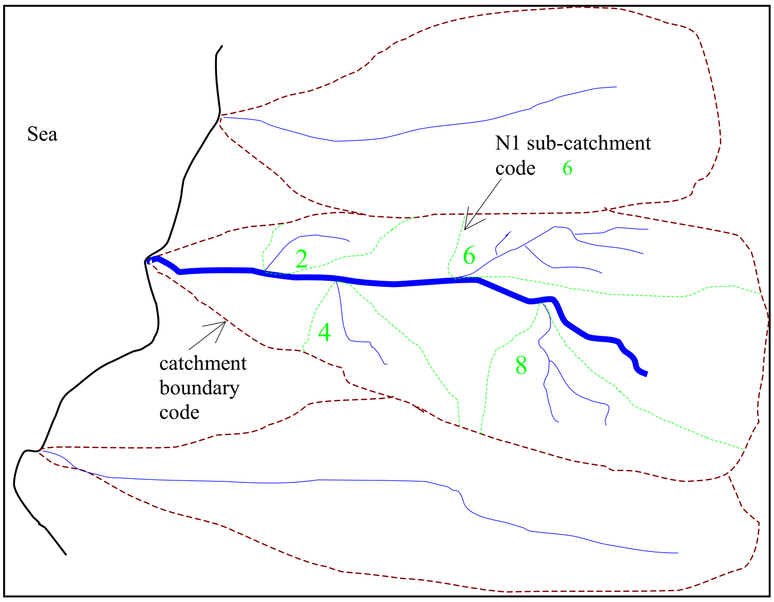


Figure 3.4.1: Pfafstetter numbering of main rivers and tributaries.

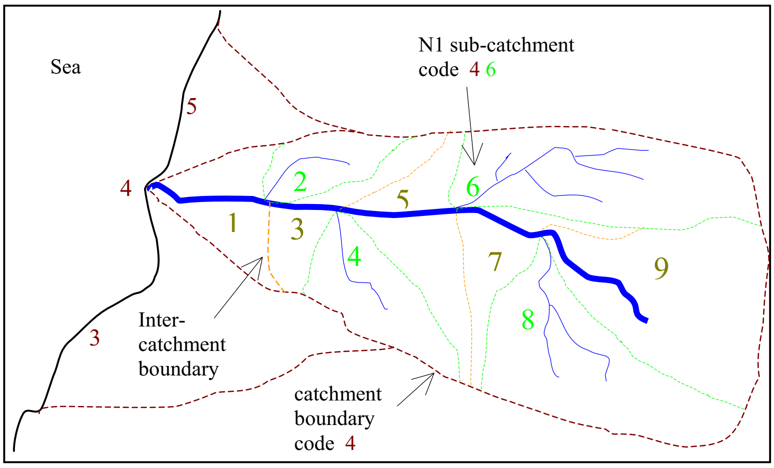


Figure 3.4.2: Defining and numbering the inter-catchment areas

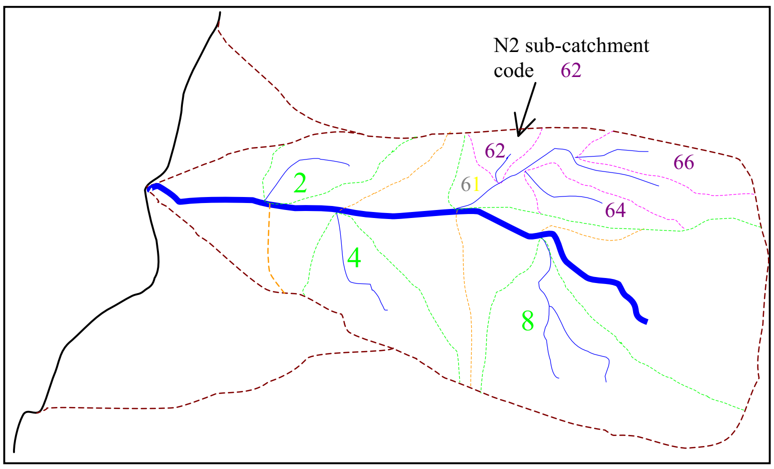


Figure 3.4.3:. Second level tributaries and inter-catchments.

Notes:
1. Use a temporary 2-digit code as IHO decimal codes are not presently suitable. These will need to be mapped to new standard 2-digit codes.

2. Portugal found that between 5 and 9 digits were required for Pfafstetter coding of the river network.

Each catchment and inter-catchment can then be broken down further in the same manner, by the use of N2. This nested process can continue into further levels. If, near the headwaters, four tributaries cannot be found, then the process continues with less catchments and inter-catchments. Alternatively, more detailed mapping is required.

Areas draining directly to sea (with diffused drainage or small rivers), will have odd numbered inter-catchment codes and can use N2 to identify the most significant rivers, then N3 for the most significant tributaries, etc.

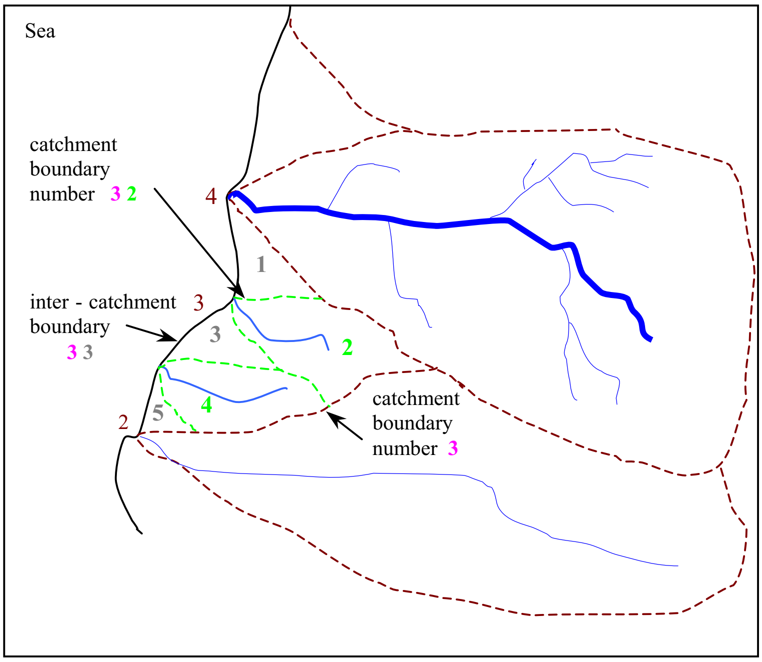


Figure 3.4.4: Sub-division of coastal catchments

The Pfafstetter approach can be used across adjacent Member States in combination with the marine waters code. Pfafstetter codes can be used directly to determine if discharge in a sub-catchment impacts on a potentially downstream channel. This can be achieved without the need for GIS analysis and is demonstrated at http://193.178.1.168/River_Coding_Review.htm.

Practical implementation issues and the impact of lakes on river coding are discussed in Appendix IV.

3.4.5 Structured Hydrological Coding for other Water Bodies

As mentioned already, the modified Pfafstetter system is an interim solution, which requires further study before it is either fully adopted as the recommended hydrological coding system or it is further modified or replaced by an alternative system. Regardless of which system is used, the river network provides a means to

a) assign unique codes to further features, and
b) assign structured hydrological codes to further features.

For example, as demonstrated in Appendix IV, if lakes, transitional water bodies and river water bodies use the same code as the downstream or outlet river stretch, then the assigned feature codes carry some level of hydrological information. This will enable rapid connectivity tests based on codes alone. Coding anomalies will arise on occasion and these will need some level of manual code assignment.

3.4.6 Protected Areas

Protected areas layers are addressed by Natura 2000 which uses a two character Member State identification code followed by a 7-character code to identify SCI's (Sites of Community Importance) and SPA's (Special Protection Areas) within a Member State.

3.4.7 Segmentation

Division of rivers or water bodies into sub-sections requires additional code management. This will not be required for initial reporting, but will be a consideration at river basin district levels. Rivers can be divided into subsections using either the sequential identifiers or the distance approaches referred to when dealing with monitoring stations in Section 3.4.3.3: *Using the River Network for Unique Code Assignments*. Similar strategies need to be put in place for coastal and lake shorelines and sub-regions.

3.4.8 Conclusion

Unique European codes should be generated by placing a 2-character Member State code in front of up to 22 characters unique identifier codes generated within Member States. This is the only requirement for compliance with an agreed common format.

Further advice is provided regarding the structure of codes; but this requires local interpretation and decision making to establish appropriate optimal formats. Member states should initially establish coding structures that suit their particular needs and that support efficient management of unique code.

It is suggested that the following be considered:

- Member states should initially assign identification codes to coding authorities;
- A decision should be made with respect to the use of structured hydrological codes;
- River segment codes should be established for all rivers likely to be used for reporting;
- Coding authority and river segment codes should then be extended to assign further unique feature identification codes at a local level;
- Monitoring station identification codes, generated by such code extensions, should not change once assigned, even if associated authority or feature identification codes do change;
- Agreement should be reached with neighbouring countries regarding harmonised cross-border codes, particularly for river network coding.

Unique European codes of standard format are of a higher priority than structured hydrological codes. However, where computers are used to identify and code features, then for little extra effort, hydrological codes can be assigned. These will facilitate rapid connectivity tests without reference to GIS.

The following tables show some example codes, all of which comply with the MS plus 22 character string format. Suggestions are made with respect to possible coding strategies. However, it will be up to Member States to determine the best approach to adopt for local use and for application in international river basin districts.

ined at Member State level, subject to existing data, local practices, organisational structures and long-term les below should then be redrafted, at Member State level, to summarise local coding standards.

	EXAMPLE ONLY	
$\#_{22}$ ..... N_{22} stetter)	IE12873 a river, GB12874 a catchment	MS = member state, at river section or catchment outlet. Non-Hydrological Approach: $\#_1,\#_2$ .. $\#_{22}$ = an up to 22 character string. Hydrological Approach: MW = marine waters codes according to a modification of codes for IHO delineations. (N_1,N_2, N_3....N_{22} are nested codes, each consisting of 1 digit With Pfafstetter, rivers use odd numbers, catchments or basins use even.)
$\#_{22}$	IE12873	For a hydrological approach use the same code as outlet river reach.
$\#_{22}$	SE13873	For a hydrological approach use the same code as outlet river reach.
$\#_{22}$	DE035411	For a hydrological approach use the same code as outlet river reach.
$\#_{22}$	IE10001230	This code may be an extension of a coding authority identification code, or it may relate to IHO marine water delineations.
$\#_{22}$	GB30002310	This code may be an extension of a coding authority identification code.

Points

	EXAMPLE ONLY	
MS $\#_1,\#_2$ .. $\#_{22}$	GR5730800	MS = Member State $\#_1,\#_2$ .. $\#_{22}$ = is an up to 22 digit code, but kept as short as possible to avoid keying errors. This code may be an extension of the river segment, catchment or water body code.
MS $\#_1,\#_2$ .. $\#_{22}$	GE5730300	This code may be an extension of the lake or lake water body code.
MS $\#_1,\#_2$ .. $\#_{22}$	GE100003001230	This code may be an extension of a coastal water body identification code.
MS $\#_1,\#_2$ .. $\#_{22}$	IT5730300	This code may be an extension of a transitional water body identification code.
MS $\#_1,\#_2$ .. $\#_{22}$	IT200001500305	This code may be an extension of a groundwater body identification code.

Points

Code Format	Example Code	Comments
EXAMPLE ONLY		
MS $\#_1,\#_2$ .. $\#_{22}$	LT124000000120	This code may be an extension of a coding authority identification code. Alternatively it might be an extension of the ground water body code. The decision should depend on the member state ongoing code maintenance strategy.
MS $\#_1,\#_2$ .. $\#_{22}$	ES130001010002	This code may be an extension of a coding authority identification code. Alternatively it might be an extension of the surface water body code. The decision should depend on the member state ongoing code maintenance strategy.
MS $\#_1,\#_2$ .. $\#_{22}$	PT130000100002	This code may be an extension of a coding authority identification code. Alternatively it might be an extension of the surface or coastal water body code. The decision should depend on the member state ongoing code maintenance strategy.

ges

Format	Example Code	Comments
EXAMPLE ONLY		
#$_2$ .. #$_{22}$	FR130002500004	This code may be an extension of a coding authority identification code. Monitoring stations could be a further extension again. Discharges may be managed by type, such as Industrial, Treatment Plant, Solid Waste Leachate, etc.

Format		
EXAMPLE ONLY		
,#$_2$ .. #$_{22}$	IE130020020123	This code may be an extension of a coding authority identification code.

3.5 Data Validation

This chapter describes the principles for quality assurance related to the GIS layers that are transmitted by the Member States to the European Commission. As pointed out earlier, the working group decided to deliver GIS layers and maps. The focus will be on reporting rather than spatial analysis. Hence the requirements on data quality are less strict compared to spatial analysis requirements. Nevertheless, there are some demands that can be derived from producing good cartography. Additionally, the GIS layers should be in a state that allows using as much as possible automated procedures for quality control. In general the data quality procedures should be applied by the Member States and be reported as part of the metadata. When compiling the national GIS layers, the EC will apply additional procedures that aim at creating homogenous GIS layers within the specifications of this Guidance Document. The framework for applying quality assurance procedures and reporting the results is set by the draft ISO standards on quality principles (19113), evaluation procedures (19114), and metadata (19115).

3.5.1 Data Quality Overview

Every GIS layer should be complemented with overview information on data quality. It consists of descriptions of the purpose, the usage and information on the history (lineage) of the GIS layer. Purpose describes the original objectives for creating the GIS layer, usage illustrates the actual usage(s) of the layer by describing related applications. The lineage gives information on the history of the dataset. It covers the total life cycle of a dataset from initial collection and processing to its current form. The lineage statement may contain the component "source information" that describes the origin of the dataset and the component "process step" that records the events of transformations in the lifetime of the dataset. Lineage also includes information on the process and the intervals to maintain a dataset.

The overview elements on data quality should be transmitted by the Members States and will be continued by the EC when applying further data processing steps.

Table 3.5.1: *Data quality overview*

Element	Obligation	reported by
Lineage statement Either a general explanation on the history, a more detailed description on the processing steps applied, or a description of the source of the GIS layer.	mandatory	MS, EC

3.5.2 Data Quality Elements

In addition to the general statements on data quality in the overview elements, the GIS layers should include information on selected data quality elements. These are completeness, logical consistency, positional accuracy and thematic accuracy.

Table 3.5.2: Selected data quality elements and sub-elements

Quality Element	Quality Sub-Element
Completeness	Commission Omission
Logical consistency	Conceptual consistency Domain consistency Topological consistency Format consistency
Positional accuracy	Absolute or external accuracy
Thematic accuracy	Classification correctness

3.5.2.1 Completeness

Completeness is assessed relative to the GIS data model specifications, which defines the desired degree of generalisation and abstraction. All features that are described in the specifications should be present in the dataset, more features would lead to a situation of over-completeness. The related attributes should sufficiently describe the feature and the values of the attributes should be filled. Relationships between the features should be established and valid according to the product specifications.

The Member States should report on methods, which they have applied to guarantee the completeness of features in the GIS layers. This refers especially to the number of river basins and sub-basins, the number of main rivers, the surface and groundwater bodies, the monitoring stations, and the protected areas. The completeness of features is normally tested by comparing them to a universe of discourse, i.e. a GIS layer that is considered as being complete. The results of the applied procedures should be reported as part of the metadata by the Member States.

Table 3.5.3: Completeness of Features Elements

Element	Obligation	reported by
Completeness of features in GIS layers	mandatory	MS

3.5.2.2 Logical Consistency

Consistency refers to the absence of apparent contradictions in the dataset, database or transfer file. Consistency is a measure of the internal validity of a database, and is assessed using information that is contained in the database.

Due to the lack of reference data, the most important part of the quality assurance process will be the assurance of the logical consistency of the data. The consistency applies to the features, the attribute-tables as well as to the attributes, and to the relationships. The relationships comprise the defined relationships between feature classes and attribute classes as well as to geometric relationships, e.g. sub-basins are covered by river basins.

Conceptual Consistency

The checks for conceptual consistency should include checking for the existence of the feature classes, the attribute classes, and the relationships that are defined in the model. The next step is to verify the existence and the correct definition of the features, attributes, domains, and relations in the database. Then it should be verified that attribute values exist, where these are defined, and that the relations are valid. The cardinality of the relations should conform to their definition. These quality checks will be applied by the EC when integrating the national GIS layers into the EU geographical database.

In the data model it is expressed that simple features are stored in the feature classes. Consequently it should be verified that the features in the database are consistent with the definition of simple features. This includes, for example, that polygons are closed, that boundaries of the polygons must not intersect, and that holes and exclaves ?? are considered correctly. Quality assurance on the validity of simple features are vital for the consistency of the database and should be applied by the Member States and reported by the EC.

Table 3.5.4: Conceptual Consistency Elements

Element	**Obligation**	**reported by**
Existence of GIS layers, attribute tables, relationships, domains	mandatory	EC
Definition of attribute	mandatory	EC
Existence of attribute values, where mandatory	mandatory	EC
Verification of cardinality of relationships	mandatory	EC
Simple features definition	mandatory	EC

Domain Consistency

In the data model, a number of domains are defined. It should be verified that the definition of the domains is correct. Then it should be checked that the attribute values in the feature and attribute classes are consistent with the domain values. In addition to the existing domains, so-called value range domains should be set up, as soon as the dimensions for the items concerned are defined. The checks on domain consistency should be applied by the Member States and will be verified during the integration process that generates the European database.

Table 3.5.5: Domain Consistency Elements

Element	**Obligation**	**reported by**
Comparison of attribute values with domain definitions	mandatory	EC

Topological Consistency

There are a number of GIS layers and attributes that can be tested for topological consistency. Some of the GIS layers have a country indication. The Member States should ensure that the appropriate country code is used.

The water bodies have an attribute indicating the relation to the EcoRegion GIS layer. The relation between water bodies and its parent river basin district can be verified by overlaying the water bodies with the river basins. The EC will test the correctness of the assignment by overlaying the respective layers.

The Appendix V contains a set of topological rules applicable to the GIS layers. The rules will be tested by the EC when merging the national GIS layers. The correctness should be reported as part of the data quality element topological consistency.

The WFD database will be set up as a collection of data sets provided by the EU countries. It is recommended that the features crossing boundaries should be coherent. This principle should apply to the geometry as well as to the attributes, e.g. the boundaries of river basins should meet at the border. The coding of the basin should be the same. The feature classes which could cover more than one country are in principle all polygon and line features, i.e. water bodies and river basins, sub-basins. This situation will be analysed by the EC when integrating the national GIS layers into a European database.

It is recommended that the hydrographical GIS layers should constitute a network. The directions of the lines should indicate flow directions. Flow lines should connect the incoming and outgoing river lines through a standing water body (e.g., lake). These connecting flow lines are termed *continua* in the data model. The data will be analysed by the EC when integrating the national GIS layers.

Table 3.5.6: Topological Consistency Elements

Element	Obligation	reported by
Coherence of features crossing country border	mandatory	EC
Country attribute values	mandatory	EC
Indication and verification of water flow	optional	EC

3.5.3 Accuracy

Positional Accuracy

Positional accuracy describes the difference between the location of features in a dataset and the location recognised as being true. The product specification in the Appendix V includes values for the minimum positional accuracy of the different GIS layers. The assessment of the positional accuracy can be done through sampling procedures.

The Member States should include information on positional accuracy and on the validation procedures applied as part of the metadata information. If there is no information on the positional accuracy, we recommend applying the method of the Federal Geographic Data Committee for geospatial positioning accuracy standards[1].

Table 3.5.7: Positional Accuracy Element

Element	Obligation	reported by
Positional accuracy	mandatory	MS

3.5.4 Descriptors of the Data Quality Sub-Elements

The results of the quality assurance for the above mentioned data quality sub-elements should be described using seven descriptors. The descriptors comprise the

- scope;
- measure;
- evaluation procedure;
- result;
- value type;
- value unit; and
- date.

of the data quality sub-element.

Quality measurements are only valid for defined scopes. The scope can be a geographic or a temporal extent, or a certain level of the data hierarchy (i.e. dataset series, dataset, features, or attributes). The scope may even be different within a single dataset, e.g. if the dataset is merged from different data providers.

The data quality measure describes briefly the test that is used for measuring the quality within the defined scope. The evaluation procedure should be described or, alternatively, there should be a reference to where a detailed description of the procedure can be found. This description is very important because it is necessary to understand the result of the applied test. Each test yields a certain result that is part of the data quality report. In order to understand the result, it is necessary to give information on the type of the value and on the unit of measurement. The reporting is completed with the date on which the quality test is performed.

3.5.5 Reporting of Quality Information

The results of the applied quality tests should be reported as part of the metadata. The DIS 19115 provides a defined structure, that follows the logic of the above described data elements, sub-elements and descriptors. The metadata standard distinguishes between data quality information as a report and as information of the history (lineage) of the data. The report comprises information on quality measurements, grouped according to the data quality sub-elements.

[1] see : http://www.fgdc.gov/standards/status/sub1_3.html

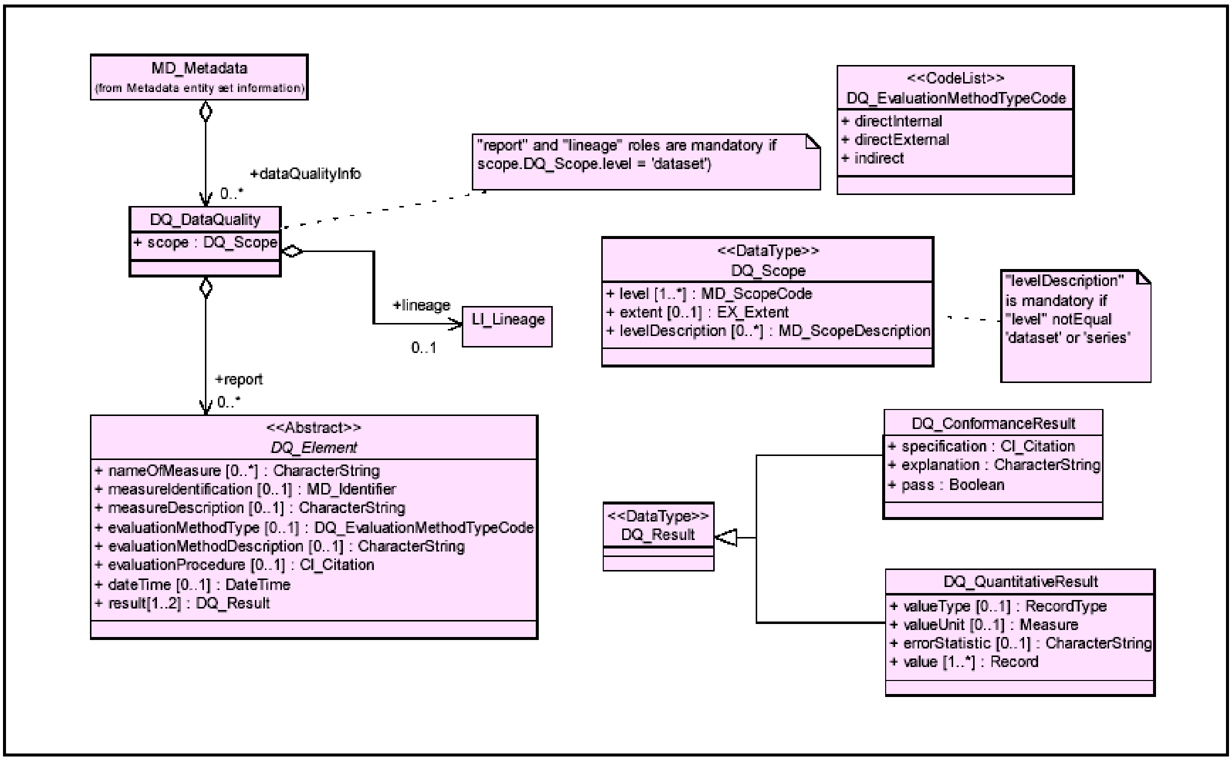


Figure 3.5.1: Conceptual model of metadata description on data quality

Appendix V contains topological rules, applicable to the GIS layers and some examples for reporting on data quality according to ISO 19115. The proposed elements of the DIS 19115 on metadata for reporting on data quality are described in the metadata part in Appendix V.

3.6 Reference System

The use of a common geodetic datum (horizontal and vertical) is a first step towards the harmonisation of geographic information across Europe. The adoption of a common reference system makes it possible to maintain seamless distributed geographic data, assigned to different custodians and avoiding or simplifying the work of geometric harmonisation. A common geodetic datum is particularly important for geographic information system users that require a "seamless" dataset. Furthermore, the fact that spatial data provided by Member States are often insufficiently documented (e.g., the used Datum is unknown or only partially or ambiguously described), is a source of errors when national data are converted to a European system. To avoid these problems, it will be the responsibility of Member States to provide data according to the proposed European datum.

ETRS89[2] is recognised by the scientific community as the most appropriate European geodetic datum to be adopted. It is defined to 1cm accuracy, and is consistent with the global ITRS[3]. ETRS89 is now available due to the creation of the EUREF[4] permanent GPS station network and the validated EUREF observations. It is already part of the legal framework of some EU Member States. Since 1989, ETRS89 co-ordinates, fixed in relation to the European

[2] ETRS : European Terrestrial Reference System
[3] ITRS : IERS Terrestrial Reference System (IERS : International Earth Rotation Service)
[4] EUREF : European Reference Frame

Plate, have regularly shifted from their values expressed in ITRS. However, this shift is well known, monitored by IERS[2] and EUREF, and transformations from one to the other are possible for most part within a 1 cm accuracy [1][2]. Appendix VI contains the full description of ETRS89 following the ISO19111 "Spatial Referencing by co-ordinates" standard [5].

The IAG[5] sub-commission for Europe (EUREF) has now defined a European vertical datum based on the EUVN[6] /UELN[7] initiative. The datum is named the EVRS[8] and is realised by the EVRF2000.

The National Mapping Agencies (NMA) or comparable Institutions / Organisations provided the information for the descriptions of the national Co-ordinate Reference Systems and for the transformation parameters between the national Co-ordinate Reference Systems and the European Co-ordinate Reference System ETRS89. Formulae can be requested from the NMAs or are directly accessible at http://crs.ifag.de/.

We give the following recommendations, partly described in the INSPIRE Architecture & Standards Final Position Paper [4]:

Geodetic framework

- *To adopt ETRS89 as geodetic datum and to express and store positions, as far as possible[9], in ellipsoidal co-ordinates, with the underlying GRS80 ellipsoid [ETRS89;.*
- *To use official formulae provided by NMAs or comparable National Institutions for the transformation between National Co-ordinate Reference systems and the ETRS89;*
- *To document National Co-ordinate Reference systems according to ISO19111;*
- *To further adopt EVRF2000 for expressing practical heights (gravity-related).*

Projection systems

There is a need for co-ordinate reference systems for pan-European applications for many statistical purposes (in which area should remain true) or for purposes such as topographic mapping (where angles or shapes should be maintained). These needs cannot be met through usage of the ETRS89 ellipsoidal co-ordinate reference system alone, and some map projections are required to supplement the ellipsoidal system (because the mapping of the ellipsoid cannot be achieved without distortion, and because it is impossible to satisfy the maintenance of area, direction and shape through a single projection).

[5] IAG : International Association of Geodesy
[6] EUVN : European Vertical Reference Network
[7] UELN : United European Levelling Network
[8] EVRS : European Vertical Reference System
[9] For some data (e.g., cadastral data), the adoption of geographical co-ordinates is not feasible in the short term and projected data should be accepted.

For applications we recommend the following projections [3]:

- for statistical analysis and display: a ETRS89 Lambert Azimuthal Equal Area co-ordinate reference system of 2001 [ETRS–LAEA], which is specified by ETRS89 as datum and the Lambert Azimuthal Equal Area map projection;
- for conformal pan-European mapping at scales smaller or equal to 1:500,000: ETRS89 Lambert Conic Conformal co-ordinate reference system of 2001 [ETRS–LCC], which is specified by ETRS89 as datum and the Lambert Conic Conformal (2SP) map projection;
- for conformal pan-European mapping at scales larger than 1:500.,000: ETRS89 Transverse Mercator co-ordinate reference systems [ETRS–TMzn], which are specified by ETRS89 as datum and the Transverse Mercator map projection.

Within the reporting activity of Water Framework Directive, the use of projected data could be necessary if some raster data (or maps) must be provided. In this case, and if a unique projection system is desirable, the use of ETRS–LCC seems the most appropriate.

3.7 Metadata

The aim of this Section is to clarify the position of the WFD GIS Working Group on geographic information metadata standards, and to provide practical technical guidance for the implementation of metadata.

Metadata is the information and documentation, which makes data understandable and shareable for users over time (ISO 11179, Annex B).

We can distinguish different types of metadata of increasing detail:

- Metadata for Inventory (i.e. internal to an organisation);
- Metadata for Discovery (i.e. necessary for external users to know who has which data, where to find them, and how to access them); and
- Metadata for Use (i.e. a fuller description of an information resource that enables users to make a judgement about the relevance and fitness-for-purpose of the resource before accessing it).

Appendix VII provides more information about standardisation activities in this field as well as more precise specifications for this standard.

Metadata standards are important as they unify the way in which data can be inventoried, discovered, and used. At the time of writing , no international standard on metadata is available. The resolution of the 14th plenary assembly of ISO TC 211 (Bangkok, 24-25 May 2002) has stated that the ISO standard No. 19115 Geographic Information – Metadata will be kept in the status FDIS[10] and the date of publishing of this standard was postponed to December 2002 [1].

[10] FDIS: Final Draft International Standard

However, taking into account the timeframe for the implementation of the Water Framework Directive, it seems reasonable to make the following proposal:

It is proposed to adopt the final draft international standard *ISO/FDIS 19115 Geographic Information - Metadata* and also to suggest some measures for the transition phase in order to minimise the impact on those countries using National or CEN pre-standards (TC 287 ENV 12 657).

It is recommended that in the mean time both the current draft of *ISO/TC211 19115 Geographic Information - Metadata*, and the suggestions of the Dublin Core (DC) metadata initiative for cross-IT searching are used.

Until the ISO 19115 standard is "officially" available and translated in all European languages, existing standards or pre-standards are acceptable. The countries deciding not to adopt ISO 19115 in the FDIS status should, however, adapt their metadata to ISO when the official standard is available. They should at least provide the mapping of the used standards to ISO 19115.

3.7.1 Scope of ISO 19115

The ISO 19115 defines the Scheme required for describing geographic information and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data.

This ISO 19115 is applicable to:

- the cataloguing of datasets, clearinghouse activities, and the full description of datasets;
- geographic datasets, dataset series, and individual geographic features and feature properties.

This ISO 19115 defines:

- mandatory and conditional metadata sections, metadata entities, and metadata elements;
- the minimum set of metadata required to serve the full range of metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data);
- optional metadata elements – to allow for a more extensive standard description of geographic data, if required;
- a method for extending metadata to fit specialised needs.

3.7.2 Core and Mandatory Elements of ISO 19115

The ISO 19115 consists of 22 core elements of which 12 are mandatory to comply with the international standard. The elements are described in Table 1 in Appendix VII. The mandatory elements focus on the discovery aspect of the metadata (catalogue purposes). Despite information on the metadata itself, they provide information on the title, the category, the reference date, the geographic location, and a short description of the data and the data provider.

The core set expands the mandatory elements with additional information on the type, the scale, the format, the reference system and the data lineage. These elements give rough information on the potential usage of the data.

For shared usage of the WFD spatial data, additional information on the data is necessary. The additional elements should include more detailed information, for example, on data quality or legal aspects of data usage.

3.7.3 Metadata Profile

The ISO 19115 for metadata comprises about 300 elements that exhaustively describe an information resource. Most of these elements are defined as being optional, i.e. they are not needed for compliance with the international standard but are defined for helping users to understand exactly the described data. Individual communities, nations, or organisations may develop a "community profile" of the standard according to their needs by selecting a set of metadata elements to be considered mandatory. A profile consists of the core metadata elements, and an additional set of optional elements that are then declared as a mandatory part of the profile. Additionally, a profile may add elements, i.e. extensions that are not part of the international standard.

The ISO 19115 describes rules for defining community profiles and extensions. A profile must not change names, the definition or data types of metadata elements. A profile must include all core metadata elements of a digital geographic data set, and all mandatory elements in mandatory and conditional sections, if the data set meets the condition required by the metadata element. Relationships between the elements have to be identified. Finally, the profile has to be made available to any user of the metadata.

A profile has to follow the rules for defining extensions. Metadata extensions are used to impose more stringent obligations on existing metadata elements. In addition, an extension can limit or extend the use of domain values for describing metadata elements.

The specific needs of reporting are not fully covered by the ISO 19115 mandatory elements neither by the core elements because they are not sufficient to describe data quality and legal aspects of data usage (see also Appendix VII).

There is agreement in the WFD GIS working group that the creation of a specific metadata profile for the Water Framework Directive is necessary.

The creation of a specific profile for the Water Framework Directive is highly recommended. The profile shall include the core elements and additional elements that are identified as necessary. The profile shall be mandatory for the data provided under the WFD reporting scheme.

The metadata profile to be developed:

- shall follow the rules laid down in ISO 19115 for creating metadata profiles;
- shall include a model for metadata;
- shall define common methods and formats for metadata exchange;
- shall be applicable to data sets and in addition to other appropriate levels of the data hierarchy;
- shall include the core elements and additional elements that are identified as necessary;
- shall include the data quality elements and the legal aspects elements described in Appendix VII;
- shall cover multilingual aspects.

Code lists shall be defined in all official languages of the European Union.

A thesaurus shall be generated to define the relationship between corresponding names in the different languages. Also text presentation should be possible in all European languages. As an alternative the adoption of a common language should be considered.

The metadata profile will be developed under the INSPIRE initiative. National WFD representatives should participate in the definition of the INSPIRE profile. This profile should be available by mid 2003 and should preferably be formally endorsed by CEN.

The metadata profile shall be reviewed in regular time intervals and if necessary adapted to new needs or developments in the GIS field.

In a later stage, the Member States shall also identify a competent authority for co-ordinating the national producers of data, for collecting and for managing the metadata. Metadata shall be kept up-to-date. Whenever data changes occur that might affect the current metadata content, the metadata have to be updated as well.

It is recommended that the metadata shall be implemented within a geographic data service (clearinghouse) on a wide area network and that Member States shall allow access to metadata via catalogues (INSPIRE will define the standard to be used for catalogue services). It is further recommended that a direct link between metadata and the described data should exist.

Acknowledgement

This Section and Appendix VII contain terms and definitions taken from ISO/DIS 19115, Geographic Information – Metadata [1]. They are reproduced with the permission of the International Organisation for Standardisation, ISO. This standard can be obtained from any ISO member and from the Web site of the ISO Central Secretariat at the following address: www.iso.org.

Some of the ideas/proposals presented in this Section are drawn from documents produced by European projects like ETeMII [2] and Madame [3], from software manuals [4] and from the collaboration between JRC, Eurostat GISCO and the EEA.

3.8 Standards for Data Exchange and Access

The way data is collected and stored, its quality and coverage will vary from organisation to organisation. In order to reduce the likelihood of data being unusable by the Commission, common exchange formats need to be agreed. This also speeds up the quality assurance issue and makes the data readily available to other Member States. It is not sensible to nominate any one proprietary format as this may limit the software options of the Member States.

There is also the need to explore the options available to allow the enhancement of data delivery in the future. The priority however is the reporting needs in the short term. In this document short term refers to the delivery of data to the Commission in 2004. The longer-term goals are targeted at data delivery in 2009.

3.8.1 Short-Term Data Exchange and Minimum Long-Term Requirements

The **best practice** will be data exchange using Geography Markup Language (GML). GML is an XML encoding for the transport and storage of geographic information, including both the geometry and properties of geographic features. Many of the current commercial GIS packages offer the facility to import data in a GML format. The current versions of most GIS's do not offer the ability to directly export in GML. There are however, several data translators on the market which provide this functionality (an example is "Feature Manipulation Engine", more information at www.safe.com).

Using GML removes many of the problems caused by file conversion by some commercial and non-commercial GIS programmes. This also supports the long-term goal of using OpenGIS or other web based technologies for data transfer. The current version is GML Version 2.1.1. Later versions (as and when they become available) may be used. However the default will be 2.1.1. For further information see http://www.opengis.net/gml/02-009/GML2-11.html.

Conforming to the OGC Simple Features model, GML provides geometry elements corresponding to the following Geometry Classes:

- Point;
- LineString;
- LinearRing;
- Polygon;
- MultiPoint;
- MultiLineString;
- MultiPolygon;
- GeometryCollection.

In addition, it provides a Co-ordinates Element for encoding co-ordinates, and a Box Element for defining extents. The details of the encoding for each of these types of geometries can be found in Appendix VIII.

The **minimum** data exchange standard for vector data will be in a recognised open published standard file format. An example is the 'shape file' format (www.esri.com/library/ whitepapers/pdfs/shapefile.pdf) that is compatible with the systems operated by the Commission or their nominated third parties. The exchange format will need to support points, lines and area features. Each feature must also have corresponding attribute data. This format will consist of at least the following:

- *Main file*: This is a direct access, variable-record-length file in which each record describes a shape with a list of its vertices;
- *Attribute file*: This contains feature attributes with one record per feature. The one-to-one relationship between geometry and attribute is based on record number. Attribute records in this file must be in the same order as the Main file. The attribute file is best supplied in a tabular format that can be read by most software packages including text processors. An example of an open standard format is Dbase IV.

The main file and the attribute file must have the same prefix. It is important in the shape file format that the first record in the main file contains the geometrical extent of the whole dataset.

The file must be able to handle integer (signed 32-bit integer (4 bytes)) and double-precision numbers (signed 64-bit IEEE double-precision floating point number (8 bytes)). The floating point numbers must be a numeric value.

The main file should contain a fixed-length file header (100 bytes) followed by variable-length records. Each variable-length record is composed of a fixed-length record header followed by variable-length record content.

The attribute file contains feature attributes. Fields present in the table should reflect the requirements of the data model. Another requirement is that the file name must have the same prefix as the main file. The table must contain one record per shape feature and the record order must be the same order as in the main file.

When non-geometric data are to be exchanged, the recommended standard is the ASCII COMMA DELIMITED format. In this format tabular data are written down per row. Fields are separated by comma (,) and strings are recognised by double quotes (“”). Dates are reported in the YYYYMMDD format as a numeric value. The first row contains the fieldnames. The advantage of this format over a fixed position format is its flexibility. Also the use of reserved characters like 'TABs' or '@' tends to fail in user communities crossing various borders and languages.

3.8.2 Long-Term (Data Access)

The proposal for the long-term is to apply state of the art Geographic Information Technology focussing on accessing geographic data through custom internet browsers directly from the Member States.

Currently the technology is based on the Web Mapping (WM) standard for data transfer, focussing on maps as set by the International OpenGIS Consortium. Within the European Commission as well as some Member States this standard is currently successfully applied and appreciated for it simplicity and extendibility. However, the weakness of this system is the fact that it only delivers raster maps and is not feature oriented. There is also a need to ensure that the requirements of the INSPIRE initiative are considered, along with any developments in the technology providing this service.

Any web application requires at least two computer systems. The Client and the Server. The Server delivers data, the Client requests data. Typically a client needs a protocol to request a given selection of data which are available on the Server. In the WM standard, the clients primary interface will be the web browser. The request protocol is resolved in a so-called URL (Uniform Resource Locator). The latter can be specified in a manner as defined in the protocol.

The URL consists of two basic components:

- The URI or the Uniform Resource Identifier, which is commonly known as the web address. On this address (the Server) the software is running that can respond to the request. Example is http://www.opengis.org/cgi-bin/getmap?

- The request part in the WM standard consists of a group of parameters that is typically needed for mapping problems.

Using this standard, an interface be can set up that allows the user to map data from various sources in one interface. The server delivers an image containing the map. The client takes care of the ability to create a user-defined request.

Along with ?compliance to the standard, the following considerations are also important:

- A data source is identified by the URI part of the URL. All other components should be named equal;
- Important in this equality is especially the naming and corresponding standard symbology of the various layers;
- Note that one layer can have more 'styles';
- While mapping data for a giving bounding box with height and width, the client implicitly requests for data at a certain map scale. The symbology should account for this property. For example small rivers should not be displayed when viewing a map on 1:1000,000 scale. When zooming-in these small rivers should appear.;
- All data sources must be mutually consistent in geometric space. Thus a river mapping in Spain should not occur in a data source from France. Most polygon layers may not overlap in space and most line layers must connect both in horizontal space as well as in vertical space. For specific modelling issues it might be necessary that data is sent

from an upstream data source to a downstream data source in order to proceed with correct calculations of cumulated values;

- For ease of use all data will be served by default in geographic co-ordinates. Later versions might explore the various national or regional projection systems;
- In order to allow geometric overlap of various datasets, specific requirements might apply on the large-scale geometric quality of two bordering data sources.

The use of Web Mapping for the delivery of data to the Commission and beyond is hoped to become best practice. It is understood that there may be some technical or political difficulties, which may make this impossible for some Member States. In this case the minimum standard of data exchange to the commission will be GML as described above.

3.8.3 File Naming Conventions.

These are discussed in detail in the introductory Section of the data dictionary (Appendix III). File naming conventions facilitate the creation of automatic procedures to generate and upload datasets. Therefore, they are an asset in themselves.

File naming conventions are important in the short-term solution. They could become trivial in the long term, when the Member States provide an access service for the Commission to their map data instead of sending files out every six years.

4 Harmonisation, Co-ordination and Organisational Issues

This Section highlights some issues on the harmonisation and co-ordination necessary in order to arrive at a seamless product for Europe. It is not possible at this stage to specify the precise steps required for a full harmonisation, both because a preliminary evaluation is required for each layer and then because the process of harmonisation hugely depends on existing data, databases and information services. The precise knowledge of the state of the play is a prerequisite for a cost/benefit analysis as well as a more precise definition of all user requirements.

We propose to adopt the pragmatic approach foreseen in INSPIRE. The long-term vision of INSPIRE is to guarantee the access to information collected and disseminated at the most appropriate level (local, regional, national and European).

However, for the successful implementation of INSPIRE a stepwise approach is proposed. The various steps could partly be carried out in parallel, depending on the WFD user needs and the degree of availability and harmonisation of existing information. All these steps involve actions of standardisation, harmonisation and integration of data and services as illustrated in Figure 4.0.1.

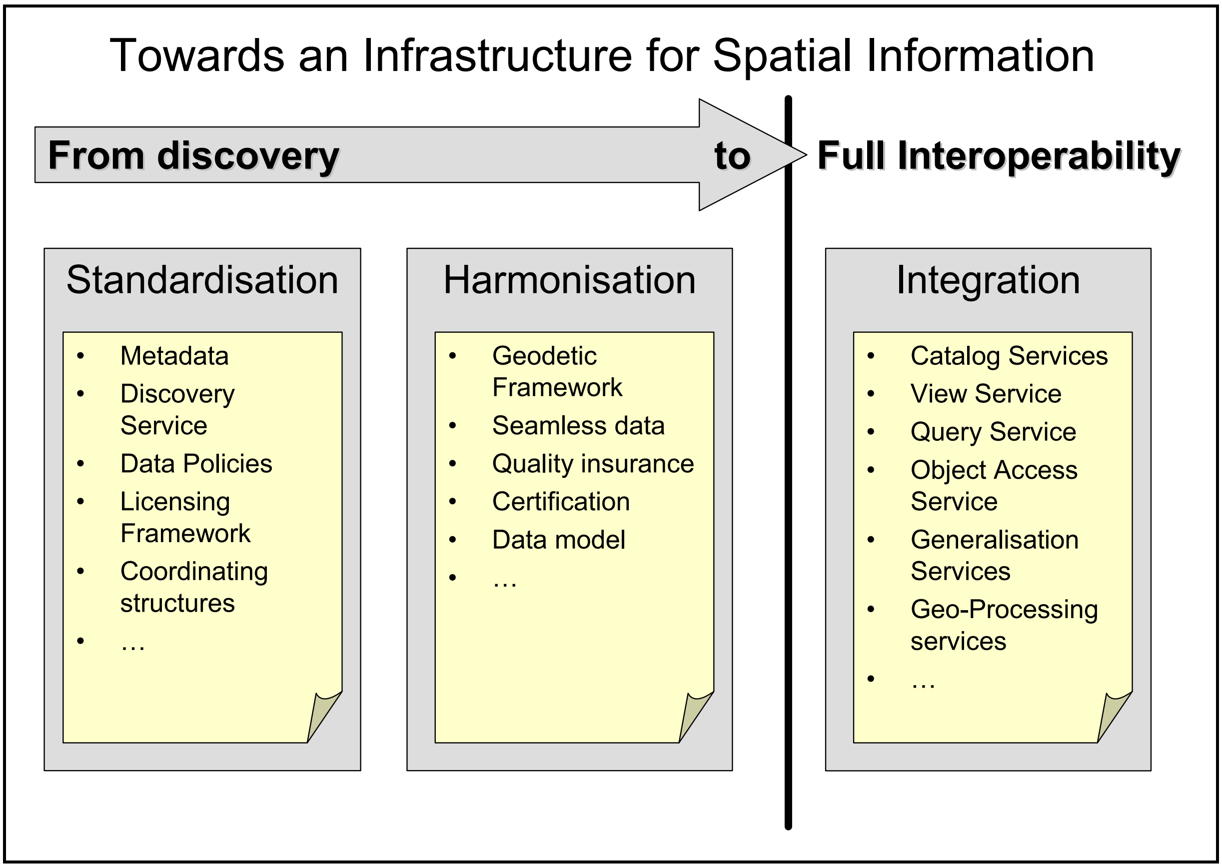


Figure 4.0.1: Towards an Infrastructure for Spatial Information

4.1 Harmonisation

The term harmonisation is used in this Section as the set of measures to be taken in order to develop a European product of comparable quality, starting from information (and services) available in the countries concerned by the WFD.

In this context we make distinction between 3 different European products:

- European seamless data;
- European database (centralised system);
- European federation of spatial data servers (de-centralised system).

The federation of servers is the final goal to be achieved in the long-term. The related harmonisation aspects will be developed under INSPIRE and should be adopted for the second reporting. These will, therefore, not be discussed here.

4.1.1 Geometric Harmonisation of Data

The need to harmonise the geometry is strictly related to the topological consistency within and between different features classes (data quality issues). This means that rivers crossing several countries should be connected and coherent in geometry and that features represented by polygons should not overlap (e.g. river basins, sub- basins and surface water bodies).

Figure 4.1.1 illustrates problems of possible overlapping or void areas in case of non-harmonised river basin district boundaries.

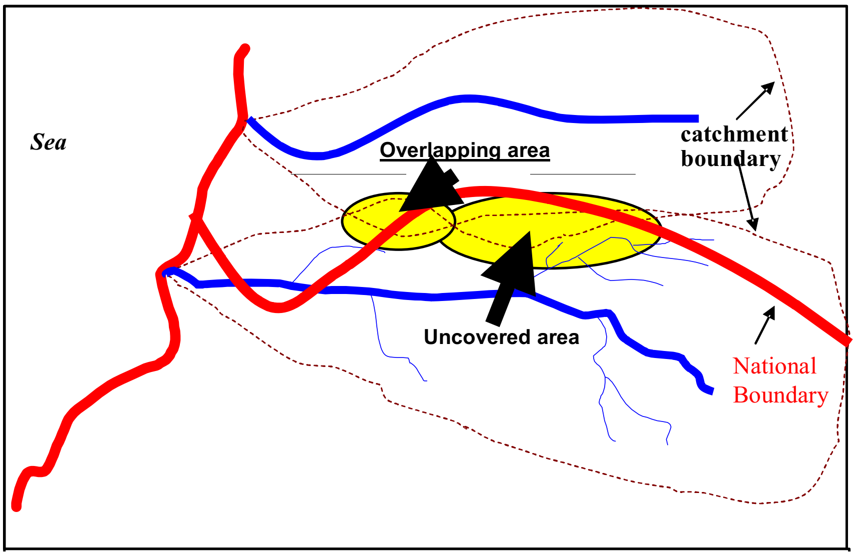


Figure 4.1.1: Possible problems due to the lack of a harmonised geometry

Geometric harmonisation is not a trivial task. We should profit from existing experiences such as SABE [1] (Seamless Administrative Boundaries of Europe) and ABDS [2] (Administrative Boundary Data Services) that show the difficulties to develop a full European operational seamless data set or service.

To obtain a common geometry, the adoption of common standards (e.g., same geodetic reference system, same positional accuracy) is not enough. Two countries should discuss and agree on the geometry to be used in the cross-boarder areas. Under the WFD, this is already foreseen as an obligation for International River Basin Districts.

To prepare a fully connected network we strongly recommend:

- The connection at the borders should be under responsibility of the Member States;
- The tolerance for connection at borders and the related accuracy should be better or equal to 1/10 of the accuracy of the dataset;
- The cartographic generalisation of data should be done at the level of the Member States;
- The use of common political boundaries (e.g., SABE) as well as of a European common layer for a coastline is strongly recommended in order to support the geometric harmonisation in the border areas.

After an evaluation of the two following options for data harmonisation:

1. Agreement on a common geometry at the beginning of the implementation phase; or
2. Harmonisation of the data at each reporting phase,

the GIS Working Group agreed to recommend option no. 1.

The adoption of the option "Agreement on a common geometry at the beginning of the implementation phase" is recommended because:

- it makes it possible to adopt a de-centralised solution in the future (in fact harmonisation is a prerequisite to do it);
- it makes it possible to have a full coherent picture of the European status (same data at European and National level); and
- in the long-term it is saving costs (the initial investment to agree on a common geometry will be recovered by the lower costs of updating and maintenance).

The main disadvantage is the initial effort to co-ordinate the harmonisation process. The following steps are necessary:

1. to agree on common data quality for reporting;
2. to discuss and harmonise the boundaries of trans-national river basin districts, including the connection of the river network;
3. to use/adopt the harmonised boundaries for national purposes;
4. to maintain the agreed boundaries as long as possible;
5. to re-start the process of harmonisation in case of changes;
6. to check that the agreed boundaries are used/maintained.

This level of harmonisation will be under the responsibility of National authorities that should apply, as far as possible, available ISO 19100 [3] series of standards for geographic information. It should be highlighted that all technical and harmonisation proposals strongly support the future implementation of a de-centralised reporting system.

In case of changes between two reporting periods, a harmonised geometry should be guaranteed at each reporting date.

4.1.2 Harmonised European database

The layers provided by the countries under the Water Framework Directive should be initially integrated in a European database (centralised system). This raises the issue whether or not to perform the vertical integration between layers (i.e. the logical and topological consistency between different features classes that refer to each other).

For the purpose of reporting, the vertical integration is not strictly required but for further analysis of the data it is a prerequisite.

The vertical integration requires these preliminary steps:

1. to adopt a common European geodetic framework (ETRS89);
2. to harmonise the geometry of different layers (harmonisation and eventually generalisation is under responsibility of Member States);
3. to connect the layers along the borders (under responsibility of Member States);
4. to adopt/support a European data model;[11]
5. to verify the topological consistency of different layers according to predefined geometric relationships.

It is recommended to use seamless harmonised reference data[12] in order to facilitate the vertical integration. The availability of such data is addressed and specifically perceived as a priority under INSPIRE (when the European Spatial Data Infrastructure will be in place, reference data will be easily available to support the "full" process of vertical integration). Until this happens other European reference data (such as EuroGlobalMap (1:1,000,000), EuroRegioMap (1:250,000) if available, or IMAGE2000) could be used as European reference for the thematic information and to support the vertical integration.

It is recommended to start the process of vertical integration limited to the layers relevant for the Water Framework Directive (excluding background layers). At the same time it is recommended to INSPIRE to consider the background layers of the Water Framework Directive as a priority for the short-term implementation.

4.2 Co-ordination

Co-ordination is a key issue for the implementation of the Water Framework Directive. The responsibilities and tasks of the Co-ordination Body or Task Force will be different in the various phases of the implementation.

It is recommended to establish a close co-operation within international River Basin Districts. This is necessary for a successful implementation.

[11] *Adoption means to use the same data model at National and European level, support means to guarantee the semantic interoperability between the National and the common European data model*

[12] According to the definition of the ETEMII white paper *"reference data is a series of dataset that everyone involved with geographic information uses to reference his/her own data as part of their work"*

4.2.1 1st Phase of Co-ordination (before the end of 2004)

In the first phase, co-ordination will be required to develop more precise specifications in collaboration with INSPIRE and to co-ordinate the harmonisation process.

It is recommended to set-up an office in charge to investigate user requirements and to support the implementation and maintenance of a de-centralised reporting system.

It is also recommended to install a thematic WG on water linked to INSPIRE that should:

1. follow-up INSPIRE developments;
2. contribute to the development of a dedicated metadata profile;
3. ensure a liaison with Framework Directive on Reporting;

5. follow-up of emerging standards for data exchange/access;
6. prepare guidelines for data product specifications;
7. ensure link to the case studies in the Pilot River Basins and integrate feedback into the Guidance Document;
8. prepare for the implementation of a European hydrological coding system, including a link to marine waters through a dedicated sub-group studying the issue;
9. investigate problems related to the analysis of underlying data and/or problems related to the analysis of pressures and impacts (subject to a request of the SCG).

Points 1-7 are related to reporting,
Points 8-9 are related to the access to underlying data and to the analysis of pressures and impacts.

Centralised system

The centralised system can be described as the European repository containing all data and some functionalities to access the information. It could be seen as the system in which the received data should first be harmonised and verified in order to correspond to the pre-defined requirements in terms of consistency (see chapter on data validation procedures).

The tasks for the Custodian of the centralised system will be the following:

1. Design and implement the centralised GIS;
2. Upgrade the centralised GIS to take into account new user requirements (e.g., resulting from the Pilot River Basin testing);
3. Data loading;
4. System maintenance;
5. Data dissemination.

Tasks 1 and 2 are mainly related to the initial stage.
Tasks 3, 4 and 5 are permanent work (heavier at each reporting phase).
Tasks 3 and 5 could be partly or completely automated, if necessary.

It is recommended to set-up an office for receiving, handling and validating data in the short-term (Custodian).

The custodian of the European database should be defined at an early stage in order to start with the system design and in order to define the procedures for data uploading and data access and dissemination.

It is also recommended to enforce the links with other WFD CIS working groups in order to consider the whole set of user requirements in the phase of system design.

4.2.2 2nd Phase of Co-ordination (2005 – 2006)

In parallel with phase 1, several steps should start in order to develop a more comprehensive and de-centralised system in the future. These steps should be co-ordinated and must involve the participation of all countries involved in order to support the implementation of the agreed European data model and to select and test the architecture of the Federation of Spatial Data Servers.

De-centralised system

While the co-ordination for a centralised system mainly implies the work of collection, harmonisation and dissemination of the data coming from Member States, a shared de-centralised architecture requires a strong co-ordination. This includes the checking of the compliance of connected systems with the technical specifications and their availability in operational mode.

The adoption of a de-centralised system implies different rules and responsibilities to guarantee the security and confidentiality of the data.

A de-centralised system in which the data (located on national servers) are directly made available by Member States, which should commit themselves to operationally run the services, is the preferred option in the long-term and is in line with INSPIRE principles.

It is recommended to adopt INSPIRE specifications for the national systems to be connected.

It is recommended to extend the mandate of the co-ordination Office or of the Custodian or to identify a new Agency to cover the additional tasks of the technical co-ordination. The tasks of this co-ordination body will include the checking of the compliance of connected systems with the technical specifications and their availability in operational mode.

5 Practical Experiences from the Prototype Exercise

This Section reports on different tests made in the frame of a prototyping exercise.

5.1 Introduction

The Water Framework Directive concerns a significant group of people involved in preparing maps and digital data to be reported to the European Commission as well as a currently less well defined user community involved in the analysis of these datasets. Both groups are hybrid in their knowledge and feeling at ease with computer technology.

Since both data preparation and analysis require advanced skills of computer technology, the GIS-WG tested some of the aspects discussed in this document in order to get deeper insight into the opportunities and problems to be expected during actual data preparation and analysis.

The prototyping effort has addressed the following topics:

1. Testing the emerging data exchange standards of ISO and OPENGIS;
2. Testing of parts of the common data model;
3. Testing the feasibility of the proposed coding mechanisms.

5.2 Emerging Data Exchange Standards of ISO and OPENGIS

During the GIS-WG meeting in March 2002 the so-called OPENGIS web mapping testbed facility was demonstrated to the GIS-WG. This technique allows generating maps on a remote server that can be visualised in common web-browsers. As a follow-up of this meeting, visual data integration was successfully demonstrated through a collaboration of JRC and Portugal. In this particular case study, a map of Portuguese river data (generated at the Portuguese web server) was overlaid with commune boundaries generated on a web server of the Commission. The example shown in Figure 5.2.1 refers to the Lisbon Area (data were projected using a Cylindrical Projection).

Following this demonstration, the members of the working group agreed that the evolving OPENGIS technology could be seen as a future aim. For the first WFD reporting period, most Member States felt, however, more at ease by sending GIS-layers or maps. Within the user communities of most Member States, the set-up of up-to-date web (map) server technology was not seen as a requirement of the Directive.

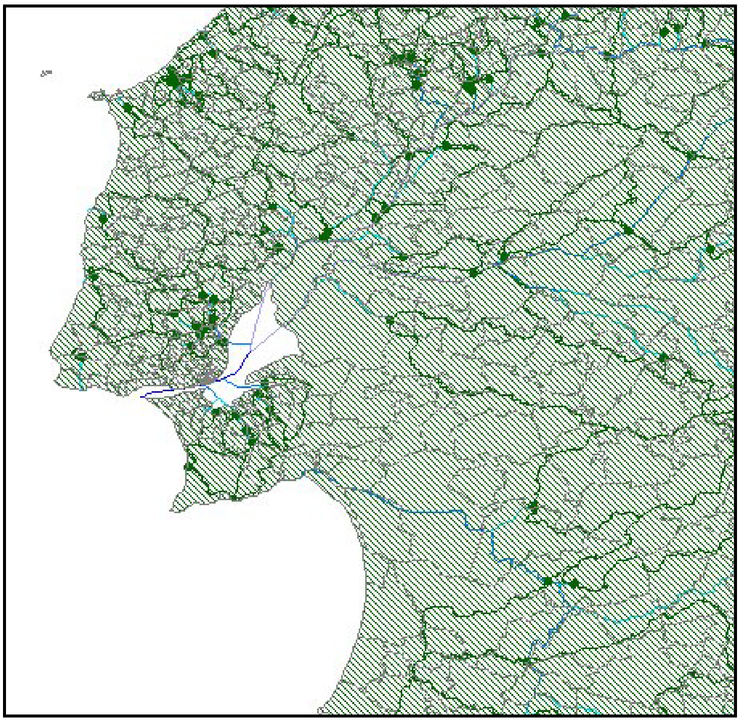


Figure 5.2.1: OpenGIS Web mapping example.

5.3 Testing of Parts of the Common Data Model

In the early discussions of the GIS Working Group, digital maps were seen as the most urgent deliverable. However, in the course of the discussions it became evident that in view of future developments more advanced solutions should be searched for.

Even though the reporting of digital maps has several advantages with respect to the delivery of analogue maps, it still prohibits the automatic analysis of the information provided. To support the latter, a common data model is needed, and the reported data need to be formatted accordingly. Such a data model is proposed in this document. Within the prototype activity, the working group defined an example web page with part of the physical model to be filled in by Member States (see Figure 5.3.1). Such web pages could help the organisations charged with sending in datasets.

By providing empty shapefiles, or ASCII delimited text files with examples, end users can be supported in setting-up the technical part of the dataset preparation. A robust finalisation of such a physical data model, in close conjunction with at least 3 pilot Member States and the presumed data custodian is an obvious recommendation that can be distilled from this activity.

Definition : Area covered by the *competent* authority, the member state part of a river basin district.
Delivered : Once by Reporter except for errors or significant change.
Implementation example : authorities.shp
Entity use in layer preparation : D7, SW1, SW3, SW4
Annex reference : I

Field name	Definition	Field type	Field length	Restrictions
MS_CD	Member state code, code allowing to refer to databases in use in the reporting organization, concatenated with the member state ISO code.	String	6	Mandatory, Primary
NAME	Locally used name, spelled in allowable characters Annex I.i	String	100	Mandatory, Unique
ADDRESS	Address for correspondence Annex I.i	String	200	Mandatory
POLYGONS	Geometric description of the district(s) managed by the competent authority, Annex I.ii	Geometry	resolution 250 meter	Mandatory, not outside territory of member state, exclusive, matching geometrically with the river basins
EU_CD	Code to be given by the data receiving organization	String	5	Feedback in 2005
INS_WHEN	Moment of insertion in the database	Date	8	Mandatory, YYYYMMDD
INS_BY	Acronym of operator responsible of insertion	String	15	Mandatory

Figure 5.3.1: Part of the example web page.

The set-up of a comprehensive inventory of the existing datasets in the Member States is a further recommendation resulting from this exercise. By giving precise guidelines on how to reformat existing datasets, Member States could be supported during data preparation.

The first data reporting will be based on so-called shapefiles and ASCII comma delimited text files. Depending on the evolution of recently introduced standards, one might expect that before 2009, when the larger parts of datasets are to be reported, most standards now mentioned have emerged to best practice.

5.4 Testing the Pfafstetter Coding Mechanism

As a perfection of the data model, it was proposed to develop a robust coding mechanism for the main entities to be reported under the WFD. The analysis of entities like river segments, lakes or catchments could benefit from a coherent coding, valid throughout the continent and its surrounding isles.

The so-called Pfafstetter coding was proposed as a means to obtain a unique numeric code at the level of each entity (e.g., river segment). The advantage of this coding is that it can be derived automatically from a consistent river network. Consequently, a user reading the Pfafstetter code of any segment can immediately understand the position of this segment in relation to other segments of the river network. Pfafstetter codes are based both on the area drained by a segment, and on the position of the segment within the network.

In the frame of the prototyping activity, an algorithm to generate this coding was developed, using the AML language. The algorithm proved that automatic generation is feasible even at detailed level. However, the river network has to be of high internal quality, especially with respect to the so-called topological relations between the segments. In addition for every river segment the area being drained is required before a Pfafstetter code can be determined. The algorithm consists of about 10 pages of AML code.

Next to coding the river segments it became evident that also the landmasses or seas are to be coded in a logical manner, in order to provide a unique code for each river segment. During the working group meeting of October 2002 a landmass coding was demonstrated as an example (see Figure 5.4.1). Note that in this example small islands within 3 km from a landmass have been coded with the same number as the adjacent landmass. It became, however, clear that a consistent sea-coding would be required, in-line with the WFD needs. The recommendation that evolved from this activity is that it is necessary to delineate sea areas in line with established international conventions, and to promote the sea code at the coastal outlet as an identifier to the upstream river network.

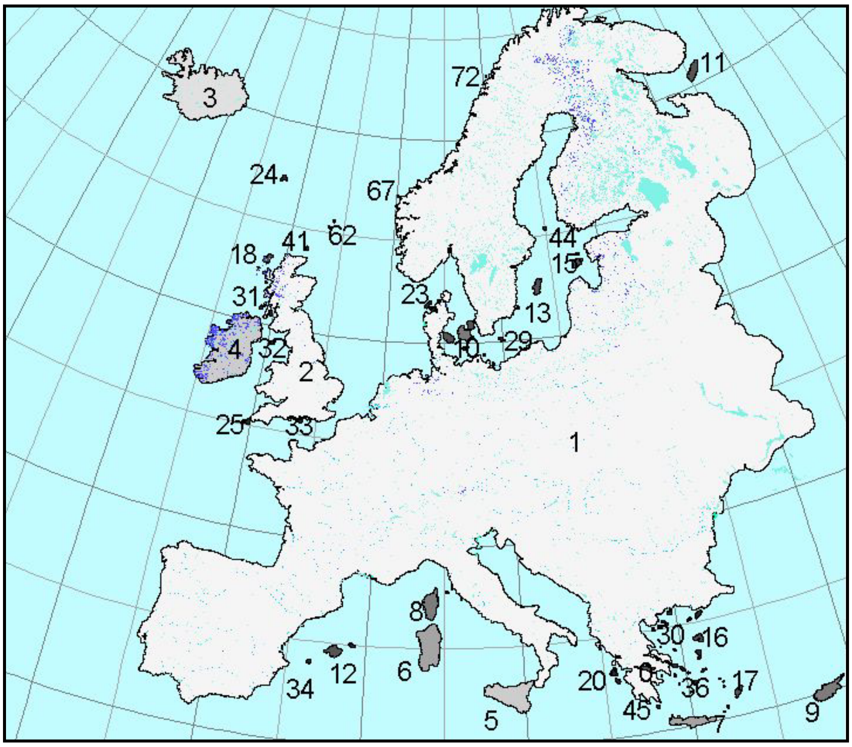


Figure 5.4.1: Example of Landmass coding based on surface area.

Figure 5.4.2 shows an example of the Pfafstetter coding for the river Thames in SE England. The outlet of the Thames in the Centre East of the map is coded ‘1’, while the source in the North West is coded ‘99’. In line with the landmass coding, the full unique code of the source of the Thames would be 2299. The first ‘2’ standing for the second largest landmass in Europe. The second ‘2’ signifying the southern-most of the 4 largest watersheds on that landmass. The fourth ‘9’ means that the source segment is subdivided one time. If we substitute the landmass code for a sea code, the first ‘2’ in the Pfafstetter code needs to be exchanged for the code of south-western North Sea, for example. Assuming that this sea code would be ‘42’, the full code would become 42299.

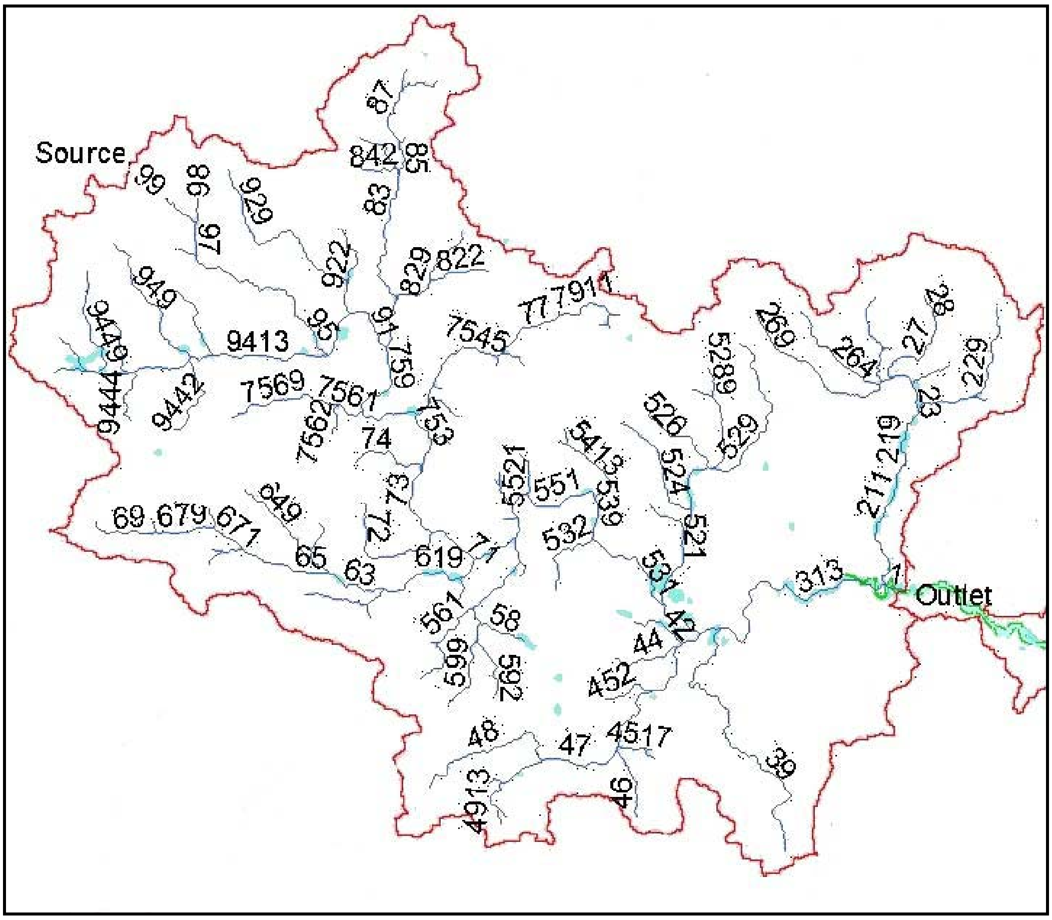


Figure 5.4.2: Example of the Pfafstetter coding of the river Thames and its tributaries.

Besides the Pfafstetter coding, other coding mechanisms are also documented in the literature. During the WG meetings, the Horton/Strahler system has been mentioned as being a valid alternative to the Pfafstetter coding, for example.

Most coding mechanisms assume flowing water along channels from the source to the sea. As a consequence, lakes, groundwater and coastal waters are not well or not at all represented. It became evident that a comprehensive coding of all water bodies covered by the WFD will require some further study, before a definite recommendation can be given.

It should be noted that any code must be regarded as a mechanism to ease analysis and to enhance communication between people about river segments. Computer systems, to the contrary, will always prefer system-generated identifiers that are in most cases logically meaningless and non-transparent to an end-user.

The JRC is about to finalise a new pan-European dataset of river segments, lakes, and catchments, automatically derived from a digital elevation model and ancillary data. This dataset, at a nominal scale of about 1:500,000, will include Pfafstetter codes and will be included in the Eurostat GISCO database. While it is not expected that this dataset can fully fulfil WFD needs, it will be a useful example for a possible implementation and an additional test. It might also help to fill important holes in the WFD generated datasets, such as the area of Switzerland.

5.5 Recommendations Resulting from the Prototype Activity

In the work of the GIS WG, the prototyping activity proved to be an important support to the theoretical discussions. Practical issues concerning data modelling, river coding and standardisation were put to the test, thus contributing to more realistic final recommendations. In a group representing more than 20 countries, cultures and manners, to organise water management, practical examples proved to stimulate discussions and to create a common awareness of the options that are available to everyone.

The coding algorithm, the example web pages for the custodian, and the practical experiences with OPENGIS map serving standards can form a starting point for an organisation yet to be defined. The set up of such an organisation will be a complicated task, not to be underestimated.

The most pertinent recommendations resulting from the activity are the following:

1. To test the proposed data model in collaboration with several Member States as well as with the data custodian;

2. To set-up a comprehensive inventory of the existing datasets currently available in the Member States;

3. To delineate sea areas in line with established international conventions and to agree on international codes for these areas.

6 Conclusions and Recommendations

The Water Framework Directive provides a legal framework for a wide range of actions, aiming to achieve good status for all waters in the European Union by 2015. Many of these actions require the handling of spatially distributed data and as such can potentially benefit from the use of Geographical Information System (GIS) technologies. In addition, the Directive explicitly calls for the reporting of most of the (spatial) information in a GIS compatible format.

Out of the range of possible GIS applications, this Guidance Document gives emphasis to the immediate reporting needs of the Water Framework Directive. As a consequence, it calls attention to the GIS layers to be prepared under the Directive and defines their characteristics (contents, spatial accuracy, time of reporting, etc.). It also underlines short-term and long-term possibilities for data exchange (i.e. centralised vs. de-centralised system), specifies how the GIS layers should be documented (i.e. metadata) and what should be done for harmonising the data across Europe. While the immediate needs of the Water Framework Directive require the set-up of a centralised system for reporting, it is noted that various initiatives at the European level, including the EAF on Reporting, strongly support the future implementation of a de-centralised system. The GIS Working Group, therefore, underlines the preference for the set-up of a de-centralised WFD reporting system in the long-term.

With respect to the level of detail of the data to be reported, the GIS Working Group strongly recommends an input scale of 1:250,000 as the common goal in the long term. However, current limitations in data availability and access require that data with an input scale of 1:1,000,000 can be used in the short-term, if they are complemented with additional objects in such a way that they meet the reporting requirements of the WFD. More detailed specifications with respect to the reporting requirements in terms of summary reporting to the Commission (small scale) and in terms of what Member States should have available upon request (large scale) will be further elaborated in the EAF on Reporting.

In addition, a European feature coding system for water bodies and catchments is proposed. The implementation of this feature coding system will be an important asset in the long-term, since it will allow for a more targeted analysis of the monitoring data and, in turn, will enable the development of a GIS with true analytical capabilities. In fact, feature coding is considered most important since it provides the link between reporting and analysis.

Due to limitations in time and due to the fact that some relevant information is not yet available for all elements of the Directive, other GIS-related aspects of the implementation could not be covered. These aspects include:

(i) the use of GIS in the analysis of pressures and impacts; or
(ii) the potential of GIS in supporting the establishment of River Basin Management Plans (e.g. the modelling of scenarios, the publication of spatial information).

It is further important to realise that also different aspects related to the reporting could not yet be definitely resolved. An example is the development of a specific metadata profile for

GIS layers emerging under the WFD. This is due to the fact that a number of international standards, which should be respected, are still under development.

The GIS-WG also decided not to include specifications on the map making process per se. This concerns not only cartographic details such as the layout, the colour codes, or the font types, but also issues of generalisation according to the map scale. We believe that the cartographic generalisation should be done at the Member State level and that the map production is best done at the level of the individual RBD authority, which will produce specific maps according to the RBD needs. At the European level, maps can be generated from the GIS layers according to the needs of the Commission. We would still recommend the set-up of a platform for exchanging experiences between the Member States and for publishing tools and colour specifications as a support to the map making process at all scales.

In addition, information technology develops at a very fast pace. As a consequence the long-term options could only be roughly outlined. As time progresses these options (e.g. the set-up of a distributed system for data reporting) will have to be further specified in accordance with evolving technical capabilities and standards.

The full implementation of an electronic reporting system will require a clear organisational structure, including the installation of a co-ordination body, capable to formulate clear requirements, to solve problems arising from the variable organisation of water management bodies in Europe, and to respond to technical questions arising from the implementation.

Finally, it should be noted that the specifications given here should be seen in the larger context of both the INSPIRE (Infrastructure for Spatial Information in Europe) initiative and the emerging Framework Directive on Reporting. The developments under these initiatives should be followed closely.

The successful implementation of the Water Framework Directive will require a close collaboration within international river basin districts. In order to ensure a harmonised data set, the GIS-WG strongly recommends using a common layer of national boundaries as well as one coastline. Also the adherence to the proposed data model is seen as an important asset in this direction.

Based on the experiences gained during the lifetime of the GIS-WG, the working group has formulated the following recommendations for the future implementation of GIS aspects under the Common Implementation Strategy:

1. It is recommended to rapidly install the office in charge of short-term receiving, handling and validating the maps and GIS layers requested under the reporting scheme of the WFD (Data Custodian). This body will be able to further co-ordinate the preparation of the requested data.

2. It is recommended to install an office in charge of investigating the user requirements and of supporting the long-term implementation and maintenance of a de-centralised reporting system. This office should enable the further development of the data model and of a European GIS for reporting.

3. It is recommended that a dedicated Thematic Working Group be installed under or linked to the INSPIRE initiative. This working group should:

   (a) follow the developments in the horizontal working groups under INSPIRE and should translate them into further guidance for the implementation of the WFD;

   (b) ensure a close liaison with the upcoming Framework Directive on Reporting;

   (c) contribute to the development of a dedicated metadata profile;

   (d) propose details for the data harmonisation process;

   (e) follow emerging standards for data exchange and access;

   (f) ensure a link to the Pilot River Basins and integrate the feedback from these case studies into the Guidance Document;

   (g) prepare for the long-term implementation of a European hydrological coding system, including a link to marine waters. This could be done through a dedicated small sub-group, studying the issue;

   (h) investigate problems related to the analysis of impacts and pressures and the analysis of underlying data, if so requested by the Strategic Co-ordination Group.

It is the hope of the members of the GIS-WG that the presented specifications will be a valuable support to the practitioners in the Member States, which are responsible for the preparation of the GIS layers and maps required under the WFD reporting scheme. In this sense, the presented Guidance Document could serve as a basis for the development of national Guidance Documents, taking into account the specific needs and circumstances of each Member State.

7 Appendices

Appendix I:The Elements of the WFD Relevant to GIS (original WFD text)

This appendix lists those parts of the Directive which directly or indirectly refer to the reporting of maps or data in a GIS compatible format. The excerpts from articles 3, 5, 13 and 20 as given at the beginning and shown in italics, are given for completeness. They do not directly refer to maps or GIS, but form the basis for the more detailed specifications in the appendices to follow.

Article 3: Co-ordination of administrative arrangements within river basin districts

1. Member States shall identify the individual river basins within their national territory and, for the purpose of this Directive, shall assign them to individual river basin districts. […] Where groundwaters do not fully follow a particular river basin, they shall be identified and assigned to the nearest or most appropriate river basin district. Coastal waters shall be identified and assigned to the nearest or most appropriate river basin district or districts.

Article 5: Characteristics of the river basin district, review of the environmental impact of human activity and economic analysis of water use

1. Each Member State shall ensure that for each river basin district or the portion of an international river basin district falling in its territory:

- *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*

is undertaken according to the technical specifications set out in Annexes II and III and that it is completed at the latest four years after the date of entry into force of this Directive.

[…]

Article 13: River basin management plans

[…]

4. The river basin management plan shall include the information detailed in Annex VII.

[…]

Article 20: Technical adaptations to the Directive

1. Annexes I, III and Section 1.3.6 of Annex V may be adapted to scientific and technical progress in accordance with the procedures laid down in Article 21, […]. Where necessary, the Commission may adopt guidelines on the implementation of Annexes II and V in accordance with the procedures laid down in Article 21.

2. For the purpose of transmission and processing of data, including statistical and cartographic data, technical formats for the purpose of paragraph 1 may be adopted in accordance with the procedures laid down in Article 21.

Annex I: Information required for the list of competent authorities

As required under article 3(8), the Member States shall provide the following information on all competent authorities within each of its river basin districts as well as the portion of any international river basin district lying within their territory.

[…]

(ii) Geographical coverage of the river basin district - the names of the main rivers within the river basin district together with a precise description of the boundaries of the river basin district. This information should as far as possible be available for introduction into a geographic information system (GIS) and/or the geographic information system of the Commission (GISCO).

Annex II

1.1 Characterisation of surface water body types

Member States shall identify the location and boundaries of bodies of surface water and shall carry out an initial characterisation of all such bodies in accordance with the following methodology. Member States may group surface water bodies together for the purposes of this initial characterisation.

[…]

(vi) Member States shall submit to the Commission a map or maps (in a GIS format) of the geographical location of the types consistent with the degree of differentiation required under system A.

Annex IV: Protected Areas

2. The summary of the register required as part of the river basin management plan shall include maps indicating the location of each protected area and a description of the Community, national or local legislation under which they have been designated.

Annex V:

1. Surface Water Status

[…]

1.3. Monitoring of ecological status and chemical status for surface waters

The surface water monitoring network shall be established in accordance with the requirements of Article 8. The monitoring network shall be designed so as to provide a coherent and comprehensive overview of ecological and chemical status within each river basin and shall permit classification of water bodies into five classes consistent with the normative definitions in Section 1.2. Member States shall provide a map or maps showing the surface water monitoring network in the river basin management plan.

1.4. Classification and presentation of ecological status

[…]

1.4.2. Presentation of monitoring results and classification of ecological status and ecological potential

(i) For surface water bodies […] Member States shall provide a map for each river basin district illustrating the classification of the ecological status for each body of water, colour coded in accordance with the second column of the table set out below to reflect the ecological status classification of the body of water […]

Ecological status classification	Colour Code
High	Blue
Good	Green
Moderate	Yellow
Poor	Orange
Bad	Red

(ii) For heavily modified and artificial water bodies […] Member States shall provide a map for each river basin district illustrating the classification of the ecological potential for each body of water, colour-coded, in respect of artificial water bodies in accordance with the second column of the table set out below, and in respect of heavily modified water bodies in accordance with the third column of that table […]

Ecological potential classification	Colour code	
	Artificial WBs	Heavily Modified WBs
Good	Equal green and light grey stripes	Equal green and dark grey stripes
Moderate	Equal yellow and light grey stripes	Equal yellow and dark grey stripes
Poor	Equal orange and light grey stripes	Equal orange and dark grey stripes
Bad	Equal red and light grey stripes	Equal red and dark grey stripes

(iii) Member States shall also indicate, by a black dot on the map, those bodies of water where failure to achieve good status or good ecological potential is due to non-compliance with one or more environmental quality standards which have been established for that body of water in respect of specific synthetic and non-synthetic pollutants (in accordance with the compliance regime established by the Member State).

1.4.3. Presentation of monitoring results and classification of chemical status

[…]

Member States shall provide a map for each river basin district illustrating chemical status for each body of water, colour coded in accordance with the second column of the table set out below to reflect the chemical status classification of the body of water:

Chemical status classification	Colour code
Good	Blue
Failing to achieve good	Red

2. Groundwater

[…]

2.2.1. Groundwater level monitoring network

[…] Member States shall provide a map or maps showing the groundwater monitoring network in the river basin management plan […]

2.2.4. Interpretation and presentation of groundwater quantitative status

Member States shall provide a map of the resulting assessment of groundwater quantitative status, colour-coded in accordance with the following regime:

Good: green

Poor: red

2.4.5. Interpretation and presentation of groundwater chemical status

[…]

Subject to point 2.5, Member States shall provide a map of groundwater chemical status, colour-coded as indicated below:

Good: green

Poor: red

Member States shall also indicate by a black dot on the map, those groundwater bodies which are subject to a significant and sustained upward trend in the concentrations of any pollutant resulting from the impact of human activity. Reversal of a trend shall be indicated by a blue dot on the map.
These maps shall be included in the river basin management plan.

2.5 Presentation of Groundwater Status

Member States shall provide in the river basin management plan a map showing for each groundwater body or groups of groundwater bodies both the quantitative status and the chemical status of that body or group of bodies, colour-coded in accordance with the requirements of points 2.2.4 and 2.4.5. Member States may choose not to provide separate maps under points 2.2.4 and 2.4.5 but shall in that case also provide an indication in accordance with the requirements of point 2.4.5 on the map required under this point, of those bodies which are subject to a significant and sustained upward trend in the concentration of any pollutant or any reversal in such a trend.

Annex VII: River Basin Management Plans

A. River basin management plans shall cover the following elements:

1. a general description of the characteristics of the river basin district required under Article 5 and Annex II. This shall include:

1.1. for surface waters:
- mapping of the location and boundaries of water bodies,
- mapping of the ecoregions and surface water body types within the river basin,
- identification of reference conditions for the surface water body types;

1.2. for groundwaters:
- mapping of the location and boundaries of groundwater bodies;

2. a summary of significant pressures and impact of human activity on the status of surface water and groundwater, including:
- estimation of point source pollution,
- estimation of diffuse source pollution, including a summary of land use,
- estimation of pressures on the quantitative status of water including abstractions,
- analysis of other impacts of human activity on the status of water;

3. identification and mapping of protected areas as required by Article 6 and Annex IV;
4. a map of the monitoring networks established for the purposes of Article 8 and Annex V, and a presentation in map form of the results of the monitoring programmes carried out under those provisions for the status of:

4.1. surface water (ecological and chemical);
4.2. groundwater (chemical and quantitative);
4.3. protected areas;

[…]

B. The first update of the river basin management plan and all subsequent updates shall also include:

[…]

1. an assessment of the progress made towards the achievement of the environmental objectives, including presentation of the monitoring results for the period of the previous plan in map form, and an explanation for any environmental objectives which have not been reached;

[…]

tasets and Layers Requested by the WFD

Other Layers	Definition	Attributes (see Data Dictionary for complete list)	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
D1, (D3)	annex I, ii) Geographical coverage of the river basin district- the names of the main rivers within the river basin district together with a precise description of the boundaries of the river basin district			1:4,000,000 Larger scale is also possible: 1:2,000,000 or 1:1,000,000		2004
	art 2, annex I, ii) 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 unit for management of river basins.	Name of river basin district, European code	Recommended: 125 metres Minimum: 1000 metres		This layer is required in digital format by the WFD. The boundaries of the river basin district are not only based on catchment boundaries, and are therefore separated from the layer river basin, sub basin	
	art 2, annex I, ii) 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)	Name of the river basin district Name of the basin/sub basin National code European code	Recommended: 125 metres Minimum: 1000 metres		Definition as in Art. 2, No. 14 WFD e.g., Mosel (G), Drau/Drawa (A)	
	Main rivers of the river basin district used for general overview (selection of rivers from SW4)	Name of river European ID of river	Recommended: 125 metres Minimum: 1000 metres		Not only a selection of the rivers of SW4, but also a generalisation	

	Other Layers	Definition	Attributes (see Data Dictionary for complete list)	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
	SW1, SW3, D4,				Recommended 1:4,000,000 Larger scale is also possible: 1:2,000,000 or 1:1,000,000	The reporting scale of 1: 1,000,000 can be necessary if the size of competent authorities is small	2004
t		annex I Area covered by the competent authority, the Member state part of the river basin district	Name of competent authority Address of competent authority Name of river basin district	Recommended: 125 metres Minimum: 1000 metres			
	D1, D4, (D3), (D5)	annex II - 1.1, 1.2, VII - 1.1 Surface water bodies are first discriminated based on categories - rivers, lakes, transitional waters or coastal waters - or as artificial surface water bodies or heavily modified surface water bodies. Within each category a discrimination is made based on type (system A or B)			Recommended: 1: 250,000 Minimum: 1: 1,000,000	Map of types described in annex II - 1.1 2) Map of waterbodies described in annex VII - A.1.1 3) Map of ecoregion and types described in annex VII - A.1.1	2009 (*)
s ed ily			Category (river, lake, transitional water, coastal water) Name European Code National Code	Recommended: 125 metres Minimum: 1000 metres		Categories are described. This layer is required in digital format by the WFD.	

	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
	SW4, D1, D4,	annex II - 1.1 - vi Same as map 3			Recommended: 1: 250,000 Minimum: 1: 1,000,000	1) Map of types described in annex II - 1.1 2) Map of waterbodies described in annex VII - A.1.1 3) Map of ecoregion and types described in annex VII - A.1.1	2004
ch			Type, number of values and underlying attributes can be different per category and between River Basin Districts	n.a. (linked to layer SW4)		Differentiation according to type (system A/B) is still in discussion by other working groups, the outcome effects layer SW4. This layer is required in digital format by the WFD.	
			Ecoregion code Name of Ecoregion	Recommended: 125 metres Minimum: 1000 metres		Ecoregion only required for map described in annex VII - A.1.1, can also be interpreted as an attribute of SW4	
	SW1, SW3, (SW2) D1, D4,	annex II - 2.1, VII - 1.2 Location and boundaries of groundwater bodies			Recommended: 1: 250,000 Minimum: 1: 1,000,000		2009 (*)
ter		Location and boundaries of groundwater bodies	Name of groundwater body ID of groundwater body	Recommended: 125 metres Minimum: 1000 metres		European coding - if accessible	

	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
	SW4 D1, D4, D5, (D2)	annex V - 1.3, VII - 4 Surface water monitoring network in the river basin management plan, the network contains also the points in the protected areas (map 12)			Recommended: 1: 250,000 Minimum: 1: 1,000,000	Possibly classified by categories	2009
g eas		annex V - 1.3.2, V - 1.3.5	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres		Inclusive monitoring sites for habitat and species protected areas (annex V - 1.3.5) and intercalibration sites	
		annex V - 1.3.1	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			
om		annex V - 1.3.5	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			
		annex V - 1.3.3	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			
g		annex II - 1.3 (iv)	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			

	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
	SW4, D1, D4, D8	annex V - 1.4.2 For surface water categories, the ecological status classification for the body of water shall be represented by the lower of the values for the biological and physico-chemical monitoring results for the relevant quality elements classified in High= Blue, Good=Green, Moderate=Yellow, Poor=Orange, Bad=Red. For heavily modified and artificial water bodies, the classification of the ecological potential is defined in a similar way.			Recommended: 1: 250,000 Minimum: 1: 1,000,000		2009
		See above	European code of SW body Ecological status: High, good, moderate, poor, bad	n.a. (linked to layer SW4)		Table related to layer SW4 (Surface water bodies)	
		Classification of the ecological potential for each body of water (artificial water bodies or heavily modified water).	European code of SW body Ecological potential: Good and above, moderate, poor, bad	n.a. (linked to layer SW4)		Table related to layer SW4 (Surface water bodies)	
al		annex V – 1.4.2-iii Those bodies of water where failure to achieve good status or good ecological potential is due to non-compliance with one or more environmental quality standards which have been established for that body of water in respect of specific synthetic and non-synthetic pollutants.	European code of SW body Non-compliant: true or false	n.a. (linked to layer SW4)		Table related to layer SW4 (Surface water bodies)	

	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
	SW4 D1, D4, D8	annex V - 1.4.3 A map for each river basin district illustrating chemical status for each body of water, colour-coded in Good = Blue, Failing to achieve good = Red			Recommended: 1: 250,000 Minimum: 1: 1,000,000		2009
		See above	European code of SW body Chemical status: Good or 'Failing to achieve good'	n.a. (linked to layer SW2)		Table related to layer SW4 (Surface water bodies)	
	GW1, SW1, SW3, D1, D4, (D2)	annex V – 2.5, VII – 4.2 Member States shall provide in the river basin management plan a map showing for each groundwater body or groups of groundwater bodies both the quantitative status and the chemical status of that body or group of bodies, colour-coded in accordance with the requirements of points 2.2.4 and 2.4.5. Member States may choose not to provide separate maps under points 2.2.4 and 2.4.5 but shall in that case also provide an indication in accordance with the requirements of point 2.4.5 on the map required under this point, of those bodies which are subject to a significant and sustained upward trend in the concentration of any pollutant or any reversal in such a trend.			Recommended: 1: 250,000 Minimum: 1: 1,000,000		2009
f		annexes V - 2.2.4, V - 2.5, VII - 4.2 Quantitative status of groundwater bodies: Good: green Poor: red	European code of GW body Quantitative status: Good or Poor	n.a. (linked to layer GW1)		Table related to layer GW1 (Groundwater bodies)	

Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
	annex V – 2.4.5, V – 2.5, VII – 4.2 Chemical status of groundwater bodies: Good: green Poor: red	European code of GW body Chemical status: Good or Poor	n.a. (linked to layer GW1)		Table related to layer GW1 (Groundwater bodies)	
	Groundwater bodies which are subject to a significant and sustained upward trend in the concentrations of any pollutant resulting from the impact of human activity (black dot). Reversal of a trend (blue dot)	European code of GW body Pollutant trend: Upward or reversed Confidence level of the trend	n.a. (linked to layer GW1)		Table related to layer GW1 (Groundwater bodies)	
GW1, SW1, SW3, D1, D4, (D2)	annex V – 2.2, V – 2.3, VII - 4 Groundwater level monitoring network; Surveillance monitoring network (chemical); Operational monitoring network (chemical).			Recommended: 1: 250,000 Minimum: 1: 1,000,000		2009
	annex V - 2.2	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			
	annex V - 2.4	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			
	annex V - 2.4	Name of site European code Country name or code	Recommended: 125 metres Minimum: 1000 metres			

	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
		annexes IV, VII - 3 Maps including the following types of protected areas as described with the layers (below)			Recommended: 1: 250,000 Minimum: 1: 1,000,000	Possibly a different map necessary for each layer	2009
	GW1 D1, D4, SW1,SW3	(i) areas designated for the abstraction of water intended for human consumption under Article 7;	ID or Name of protected area Protected area type	Recommended: 125 metres Minimum: 1000 metres			
	SW1, SW4, D1,	(ii) areas designated for the protection of economically significant aquatic species;	ID or Name of protected area Protected area type	Recommended: 125 metres Minimum: 1000 metres			
	SW1, SW4, D1, D4	(iii) bodies of water designated as recreational waters, including areas designated as bathing waters under Directive 76/160/EEC	ID or Name of protected area Protected area type	Recommended: 125 metres Minimum: 1000 metres			
	SW1, SW4, D1,	(iv) nutrient-sensitive areas, including areas designated as vulnerable zones under Directive 91/676/EEC (Nitrates Directive) and areas designated as sensitive areas under Directive 91/271/EEC (Urban Waste Water Treatment Directive)	ID or Name of protected area Protected area type	Recommended: 125 metres Minimum: 1000 metres		Possibly 2 layers	
	SW1, SW4, D1,	(v) areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant Natura 2000 sites designated under Directive 92/43/EEC (habitats) and Directive 79/409/EEC (Birds).	ID or Name of protected area Protected area type	Recommended: 125 metres Minimum: 1000 metres			
s	SW1, SW4, D1,	See above	ID or Name of protected area Protected area type	Recommended: 125 metres Minimum: 1000 metres			

	Other Layers	Definition	Attributes	Positional Accuracy	Reporting Scale	Remarks	Date of Reporting to EC
	SW1, SW4, D1,	annexes VII - 4.3 Results of the monitoring programmes carried out for the status of protected areas.			Recommended: 1: 250,000 Minimum: 1: 1,000,000		2009
			ID or Name of protected area Status	n.a. (linked to layers PA1 – PA6)		Table related to layers PA1 – PA6	
s				Recommended: 125 metres Minimum: 1000 metres			
4)		Only for reference, so bigger settlements					
				Recommended: 125 metres Minimum: 1000 metres			
t				Recommended: 125 metres Minimum: 1000 metres			

might change to 2004. See also footnote to Table 3.1.1 in Section 3.1.

Appendix III: Data Dictionary

The Data Dictionary provides a view of the data to be co-ordinated under the WFD as a generic (i.e. not dependent on any specific file format or database technology) representation as files / tables. For the attributes shown in the logical data model, a FieldName (shortened from the verbose description), a text description, a generic fieldtype and length, together with any restrictions (whether Mandatory or Optional, and any specific domains/codes to be used) are provided. Field names are shortened, primarily due to the physical restriction on field name length in commonly used data file formats (e.g. dBase – 10 characters). Fields relating to system B (WFD annex II) are shown in grey.

Classes and recommended file names are given in Table 1 below. File names are made up of a prefix (maximum 8 characters) and a suffix (3 characters). We recommend using a standard prefix for each class. The suffix will depend on the software used (see also Section 3.8).

The aim of the Data Dictionary is to provide a common understanding of the file / table structures that should be used for the WFD GIS data. The classes in the logical UML model which translate to tables are organised alphabetically as follows:

Table 1: Classes and Recommended File Names

Class	Recommended File Name Prefix
CoastalWaters	CWbody
CompetentAuthority	Compauth
EcoRegion	Ecoreg
FWEcologicalClassification	FWeccls
GroundwaterBody	GWbody
GroundwaterMonitoringStation	GWstn
GWStatus	GWstatus
LakeSegment	LWseg
LakeWaterBody	LWbody
MonitorGWBodies	GWmon
MonitorLWBodies	LWmon
MonitorRWBodies	RWmon
MonitorTWBodies	TWmon
PhysicoChemicalClassification	Pchemcls
ProtectedArea	Protarea
RiverSegment	RWseg
RiverWaterBody	RWbody
RiverBasin	Rivbasin
RiverBasinDistrict	RBD
SalineEcologicalClassification	Saleccls
SurfaceMonitoringStation	SWstn
SWStatus	SWstatus
TransitionalWaters	TWbody

CoastalWaters

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		Mandatory
EuropeanCode	EU_CD	Unique code for a waterbody at EU level	String	24	Mandatory. As per coding guidelines
Name	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a waterbody within MS	String	22	As per coding guidelines
EcoRegionCode	REGION_CD	Ecoregion to which a waterbody belongs	String	2	Mandatory. Foreign Key to REGION_CD in EcoRegion
System	SYSTEM	Type of characterization of a waterbody	String	1	Mandatory {A, B}
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYYMMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
RiverBasinCode	BASIN_CD	The code of the parent river basin (see coding system)	String		Mandatory. Foreign Key to EU_CD in RiverBasin
StatusYear	STATUS_YR	Year of reporting of waterbody characterisation	String	4	Possibly can be dropped if duplicates INS_WHEN
HeavilyModified	MODIFIED	Whether the waterbody is heavily modified	String	1	Mandatory {Y, N}
Artificial	ARTIFICIAL	Whether the waterbody is artificial	String	1	Mandatory {Y,N}
SalinityTypology	SALINITY	Salinity category according to Annex II	String	1	Mandatory {F = Freshwater O = Oligohaline M = Mesohaline P = Polyhaline E = Euhaline}
DepthTypology	DEPTH_CAT	Depth category based on mean depth	String	1	Mandatory {S = Shallow <30m I = Intermediate 30-200m D = Deep >200m}
Latitude	LAT	Definition not	Number	8,5	Mandatory if Type = B.

Attribute	FieldName	Definition	Type	Length	Restrictions
		given in WFD. Assume Latitude (in ETRS89) of mathematical centre of waterbody			Can be calculated from supplied geometry
Longitude	LON	Definition not given in WFD. Assume Longitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Mandatory if Type = B. Can be calculated from supplied geometry
TidalTypology	TIDAL	Not defined – assume same as Transitional Tidal range category according to Annex II	String	5	Mandatory if Type = B {MICRO, MESO,MACRO}
CurrentVelocity	VELOCITY	Not defined			Optional
WaveExposure	WAVE_EXPO	Not defined			Optional
MeanWaterTemp	AV_W_TEMP	Not defined			Optional
MixingCharac	MIXING	Not defined			Optional
Turbidity	TURBIDITY	Not defined			Optional
MeanSubstratComp	SUBSTRATUM	Not defined			Optional
RetentionTime	RET_TIME	Not defined			Optional
WaterTempRange	W_TEMP_RGE	Not defined			Optional

CompetentAuthority

Attribute	**FieldName**	**Definition**	**Type**	**Length**	**Restrictions**
Name	NAME	Locally used name	String	100	Mandatory
Address	ADDRESS	Correspondence Address	String	200	Mandatory
AuthorityCode	AUTH_CD	Unique code for the competent authority.	String	24	To be defined

EcoRegion

Delivered once by Commission

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		
Name	NAME	Locally used name	String	40	
EcoRegionCode	REGION_CD	Codes as specified by Annex XI	String	2	{1-25} {AT = Atlantic, NO = Norwegian, BR = Barents, NT = North Sea, BA = Baltic, ME = Mediterranean}

FWEcologicalClassification

Attribute	FieldName	Definition	Type	Length	Restrictions
StatusDate	STAT_DATE	Date for which this status assessment is valid	Date	YYYY MMDD	Mandatory
EuropeanCode	EU_CD	Unique code for freshwater body to which this status refers	String	24	Mandatory. Foreign Key to EU_CD in River / Lake
OverallStatus	ECO_STAT	Overall ecological status for the water body	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
Phytoplankton	PHYTO	Annex V 1.2.1 /1.2.2	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
Macrophyto	MAC_PHYTO	Annex V 1.2.1 /1.2.2	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
BenthicInvertebrates	BEN_INV	Annex V 1.2.1 /1.2.2	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
Fish	FISH	Annex V 1.2.1 /1.2.2	String	1	Mandatory {H = High G = Good M = Moderate

Attribute	FieldName	Definition	Type	Length	Restrictions
					P = Poor B = Bad}
HydrologicalRegime	HYDRO_REG	Annex V 1.2.1 /1.2.2	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
RiverContinuity	RIV_CONT	Annex V 1.2.1 Rivers only	String	1	Mandatory if waterbody is River {H = High G = Good M = Moderate P = Poor B = Bad}
MorphologicalConditions	MORPH_COND	Annex V 1.2.1 /1.2.2	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}

GroundwaterBody

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		Mandatory
EuropeanCode	EU_CD	Unique code for a waterbody at EU level	String	24	Mandatory. As per coding guidelines.
Name	NAME	Locally used name	String	100	Optional
MSCode	MS_CD	Unique code for a waterbody within MS	String	22	Mandatory. As per coding guidelines
EcoRegionCode	REGION_CD	Ecoregion to which a waterbody belongs	String	2	Mandatory. Foreign Key to REGION_CD in EcoRegion
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYY MMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
RiverBasinCode	BASIN_CD	The code of the parent river basin (see coding system)	String		Mandatory. Foreign Key to EU_CD in RiverBasin
Horizon	HORIZON	Unique identifier for the horizon, where separate, overlying bodies exist	Number	2	Optional
StatusYear	STATUS_YR	Year of reporting of waterbody characterisation	String	4	Possibly can be dropped if duplicates INS_WHEN

GroundwaterMonitoringStation

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE		Geometry (points)		
Name	NAME	Locally used name	String	100	Optional
EuropeanCode	EU_CD	Unique code for a station at EU level	String	24	Mandatory. See coding guidelines.
MSCode	MS_CD	Unique code for a station at MS level	String	22	Mandatory. See coding guidelines.
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYYMMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
Level	LEVEL	Station Type	String	1	Mandatory {Y,N}
Operational	OPERAT	Station Type	String	1	Mandatory {Y,N}
Surveillance	SURVEIL	Station Type	String	1	Mandatory {Y,N}
Depth	DEPTH	Depth in metres	Number	4	Optional

GWStatus

Attribute	FieldName	Definition	Type	Length	Restrictions
StatusDate	STAT_DATE	Date for which this status assessment is valid	Date	YYYYMMDD	Mandatory
EuropeanCode	EU_CD	Unique code for SW body to which this status refers	String	24	Mandatory. Foreign Key to EU_CD in GroundwaterBody
QuantitativeStatus	QUANT_STAT	Annex V 2.2	String	1	Mandatory {G = Good P = Poor}
ChemicalStatus	CHEM_STAT	Annex V 2.3	String	1	Mandatory {G = Good P = Poor}
PollutantTrend	POLL_TREND	Annex V 2.4 Not defined	String	1	Assume : {U = Upward D = Downward S = Static}
ConfidenceLevel	CONF_LEVEL	Annex V 2.4 – not defined	String	1	Assume : {H = High M = Medium L = Low}

LakeSegment

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE		Geometry (polygons)		
LWBCode	LWB_CD	Unique code of LakeWater Body to which this segment belongs	String	24	Mandatory. Foreign Key to EU_CD in LakeWaterBody
SegmentCode	SEG_CD	Unique code for the segment	String	24	Mandatory.
Name	NAME	Locally used name	String	100	Optional

LakeWaterBody

Attribute	FieldName	Definition	FieldType	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		Mandatory
EuropeanCode	EU_CD	Unique code for a waterbody at EU level	String	24	Mandatory. As per coding guidelines
Name	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a waterbody within MS	String	22	As per coding guidelines
EcoRegionCode	REGION_CD	Ecoregion to which a waterbody belongs	String	2	Mandatory. Foreign Key to REGION_CD in EcoRegion
System	SYSTEM	Type of characterizatio n of a waterbody	String	1	Mandatory {A, B}
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYY MMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
RiverBasinCode	BASIN_CD	The code of the parent river basin (see coding system)	String		Mandatory. Foreign Key to EU_CD in RiverBasin
StatusYear	STATUS_YR	Year of reporting of waterbody characterisatio n	String	4	Possibly can be dropped if duplicates INS_WHEN
HeavilyModified	MODIFIED	Whether the waterbody is	String	1	Mandatory {Y, N}

Attribute	FieldName	Definition	FieldType	Length	Restrictions
		heavily modified			
Artificial	ARTIFICIAL	Whether the waterbody is artificial	String	1	Mandatory {Y,N}
AltitudeTypology	ALT_CAT	Altitude category according to Annex II	String	4	{HIGH, MID, LOW}
GeologyTypology	GEOL_CAT	Geological category according to Annex II	String	1	{C = Calcareous, S = Siliceous, O = Organic}
SizeTypology	SIZE_CAT	Size based on catchment area according to Annex II	String	2	{S = Small 0.5-1km M = Medium 1-10km L = Large 10-100km XL = >100km}
DepthTypology	DEPTH_CAT	Depth category based on mean depth	String	1	Mandatory {V = Very Shallow <3m S = Shallow 3-15m D = Deep >15m}
Altitude	ALT	Not defined			Mandatory if Type = B.
Latitude	LAT	Definition not given in WFD. Assume Latitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Mandatory if Type = B. Can be calculated from supplied geometry
Longitude	LON	Definition not given in WFD. Assume Longitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Mandatory if Type = B. Can be calculated from supplied geometry
Depth	DEPTH	Not defined			Optional
Geology	GEOLOGY	Not defined			Optional
SizeMeasurement	SIZE	Not defined. Assume area in KM2			Optional
MeanDepth	AV_DEPTH	Not defined			Optional
LakeShape	LAKE_SHAPE	Not defined			Optional
ResidenceTime	RES_TIME	Not defined			Optional
MeanAirTemp	AV_A_TEMP	Not defined			Optional
AirTempRange	A_TEMP_RGE	Not defined			Optional
MixingCharac	MIXING	Not defined			Optional
AcidNeutCapacity	ACID_NEUT	Not defined			Optional
NutrientStatus	NUTRIENT	Not defined			Optional
MeanSubstratComp	SUBSTRATUM	Not defined			Optional
WaterLevelFluct	LEVEL_FLUC	Not defined			Optional

MonitorGWBodies

Attribute	FieldName	Definition	Type	Length	Restrictions
GWStationCode	GWSTN_CD	Code of the GW Monitoring Station	String	24	Mandatory. Foreign Key to EU_CD in GroundWaterMonitoringStation
GWBodyCode	GWBODY_CD	Code of the GW body which is monitored	String	24	Mandatory. Foreign Key to EU_CD in GroundWaterBody

MonitorLWBodies

Attribute	FieldName	Definition	Type	Length	Restrictions
SWStationCode	SWSTN_CD	Code of the SW Monitoring Station	String	24	Mandatory. Foreign Key to EU_CD in SurfaceMonitoringStation
LWBodyCode	LWBODY_CD	Code of the LW body which is monitored	String	24	Mandatory. Foreign Key to EU_CD in LakeWaterBody

MonitorRWBodies

Attribute	FieldName	Definition	Type	Length	Restrictions
SWStationCode	SWSTN_CD	Code of the SW Monitoring Station	String	24	Mandatory. Foreign Key to EU_CD in SurfaceMonitoringStation
RWBodyCode	RWBODY_CD	Code of the RW body which is monitored	String	24	Mandatory. Foreign Key to EU_CD in RiverWaterBody

MonitorTWBodies

Attribute	FieldName	Definition	Type	Length	Restrictions
SWStationCode	SWSTN_CD	Code of the SW Monitoring Station	String	24	Mandatory. Foreign Key to EU_CD in SurfaceMonitoringStation
TWBodyCode	TWBODY_CD	Code of the TW body which is monitored	String	24	Mandatory. Foreign Key to EU_CD in TransitionalWaters

PhysicoChemicalClassification

Attribute	FieldName	Definition	Type	Length	Restrictions
StatusDate	STAT_DATE	Date for which this status assessment is valid	Date	YYYYMMDD	Mandatory
EuropeanCode	EU_CD	Unique code for surfacewater body to which this status refers	String	24	Mandatory. Foreign Key to EU_CD in River / Lake / TransitionalWaters / CoastalWaters
GeneralConditions	GEN_COND	Annex V 1.2.1 /1.2.2 /1.2.3 /1.2.4 /1.2.5	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
SyntheticPollutants	SYNTH	Annex V 1.2.1 /1.2.2 /1.2.3 /1.2.4 /1.2.5	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
NonSyntheticPollutants	NON_SYNTH	Annex V 1.2.1 /1.2.2 /1.2.3 /1.2.4 /1.2.5	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}

ProtectedArea

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE		Geometry (polygons)		
Name	NAME	Locally used name	String	100	Optional
ProtectedAreaType	PROT_TYPE	Category of the protected area	String	1	Mandatory. {D = Drinking R = Recreational E = Economic Species N = Nutrient H = Habitat B = Bird}

RiverSegment

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE		Geometry (lines)		
RWBCode	RWB_CD	Unique code of RiverWaterBody to which this segment belongs	String	24	Mandatory. Foreign Key to EU_CD in RiverWaterBody
SegmentCode	SEG_CD	Unique code for the segment	String	24	Mandatory.
Name	NAME	Locally used name	String	100	Optional
Continua	CONTINUA	Whether river segment is an imaginary link segment to maintain network topology	String		Mandatory {Y, N}
FlowDirection	FLOWDIR	Flow direction with respect to digitized direction	String	1	{W = With, A = Against}

RiverWaterBody

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (lines)	Geometry		Mandatory
EuropeanCode	EU_CD	Unique code for a waterbody at EU level	String	24	Mandatory. As per coding guidelines
Name	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a waterbody within MS	String	22	As per coding guidelines
EcoRegionCode	REGION_CD	Ecoregion to which a waterbody belongs	String	2	Mandatory. Foreign Key to REGION_CD in EcoRegion
System	SYSTEM	Type of characterization of a waterbody	String	1	Mandatory {A, B}
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYYMMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
RiverBasinCode	BASIN_CD	The code of the parent river basin (see coding system)	String		Mandatory. Foreign Key to EU_CD in RiverBasin
StatusYear	STATUS_YR	Year of	String	4	Possibly can be

Attribute	FieldName	Definition	Type	Length	Restrictions
		reporting of waterbody characterisation			dropped if duplicates INS_WHEN
HeavilyModified	MODIFIED	Whether the waterbody is heavily modified	String	1	Mandatory {Y, N}
Artificial	ARTIFICIAL	Whether the waterbody is artificial	String	1	Mandatory {Y,N}
AltitudeTypology	ALT_CAT	Altitude category according to Annex II	String	4	{HIGH, MID, LOW}
GeologyTypology	GEOL_CAT	Geological category according to Annex II	String	1	{C = Calcareous, S = Siliceous, O = Organic}
SizeTypology	SIZE_CAT	Size based on catchment area according to Annex II	String	2	{S,M,L,XL}
Latitude	LAT	Definition not given in WFD. Assume Latitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Mandatory if Type = B. Can be calculated from supplied geometry
Longitude	LON	Definition not given in WFD. Assume Longitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Mandatory if Type = B. Can be calculated from supplied geometry
Geology	GEOLOGY	Not defined			Mandatory if Type = B.
SizeMeasurement	SIZE	Not defined. Assume total length in KM			Mandatory if Type = B.
DistRiverSource	DIST_SOURCE	Not defined			Optional
FlowEnergy	ENERGY	Not defined			Optional
MeanWidth	AV_WIDTH	Not defined			Optional
MeanDepth	AV_DEPTH	Not defined			Optional
MeanSlope	AV_SLOPE	Not defined			Optional
RiverMorphology	RIV_MORPH	Not defined			Optional
DischargeCategory	DISCHARGE	Not defined			Optional
ValleyMorphology	VAL_MORPH	Not defined			Optional
SolidsTransport	SOLIDS	Not defined			Optional
AcidNeutCapacity	ACID_NEUT	Not defined			Optional
MeanSubstratComp	SUBSTRATUM	Not defined			Optional
Chloride	CHLORIDE	Not defined			Optional
AirTempRange	A_TEMP_RGE	Not defined			Optional
MeanAirTemp	AV_A_TEMP	Not defined			Optional
Precipitation	PPT	Not defined			Optional

RiverBasin

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		Mandatory
Name	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a river basin within MS	String	22	As per coding guidelines
EuropeanCode	EU_CD	Unique code for a river basin at EU level	String	24	Mandatory. As per coding guidelines
DistrictCode	DIST_CD	Code for River Basin District the basin belongs to	String	24	Mandatory. Foreign Key to EU_CD in RiverBasinDistrict
AreaKM2	AREAKM2	Area in square kilometres	Number	6	Mandatory

RiverBasinDistrict

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE	Geometry (polygons)	Geometry		Mandatory
Name	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a river basin district within MS	String	22	As per coding guidelines
EuropeanCode	EU_CD	Unique code for a river basin district at EU level	String	24	Mandatory. As per coding guidelines
CompetentAuth	AUTH_CD	Code of the competent authority for the RBD	String	24	Mandatory. Foreign Key to AUTH_CD in CompetentAuthority

SalineEcologicalClassification

Attribute	FieldName	Definition	Type	Length	Restrictions
StatusDate	STAT_DATE	Date for which this status assessment is valid	Date	YYYY MMDD	Mandatory
EuropeanCode	EU_CD	Unique	String	24	Mandatory. Foreign Key

Attribute	FieldName	Definition	Type	Length	Restrictions
		code for salinewater body to which this status refers			to EU_CD in TransitionalWaters / CoastalWaters
Phytoplankton	PHYTO	Annex V 1.2.3 /1.2.4	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
Macroalgae	MAC_ALGAE	Annex V 1.2.3 /1.2.4	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad} If waterbody is coastal, refers to macroalgae AND angiosperms
Angiosperms	ANGIO	Annex V 1.2.3	String	1	Mandatory if waterbody is Transitional {H = High G = Good M = Moderate P = Poor B = Bad}
BenthicInvertebrates	BEN_INV	Annex V 1.2.3 /1.2.4	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
Fish	FISH	Annex V 1.2.3 Transitional Waters only	String	1	Mandatory if waterbody is Transitional {H = High G = Good M = Moderate P = Poor B = Bad}
TidalRegime	TIDAL_REG	Annex V 1.2.3 /1.2.4	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}
MorphologicalConditions	MORPH_COND	Annex V 1.2.3 /1.2.4	String	1	Mandatory {H = High G = Good M = Moderate P = Poor B = Bad}

SurfaceMonitoringStation

Attribute	FieldName	Definition	Type	Length	Restrictions
Shape	SHAPE		Geometry (points)		
Name	NAME	Locally used name	String	100	Optional
WaterBodyCode	BDY_CD	Unique code of parent waterbody	String	24	Mandatory. Foreign Key to EU_CD in River / Lake / TransitionalWaters
EuropeanCode	EU_CD	Unique code for a station at EU level	String	24	Mandatory. See coding guidelines.
MSCode	MS_CD	Unique code for a station at MS level	String	22	Mandatory. See coding guidelines.
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYYMMDD	Mandatory
InsertedBy	INS_BY	Acronym of operator	String	15	Mandatory
Depth	DEPTH	Depth in metres	Number	4	Optional
Drinking	DRINKING	Station Type	String	1	Mandatory {Y,N}
Investigative	INVEST	Station Type	String	1	Mandatory {Y,N}
Operational	OPERAT	Station Type	String	1	Mandatory {Y,N}
Habitat	HABITAT	Station Type	String	1	Mandatory {Y,N}
Surveillance	SURVEIL	Station Type	String	1	Mandatory {Y,N}
Reference	REFERENCE	Station Type	String	1	Mandatory {Y,N}

SWStatus

Attribute	FieldName	Definition	Type	Length	Restrictions
StatusDate	STAT_DATE	Date for which this status assessment is valid	Date	YYYYMMDD	Mandatory
EuropeanCode	EU_CD	Unique code for SW body to which this status refers	String	24	Mandatory. Foreign Key to EU_CD in River / Lake / TransitionalWaters / Coastal Waters
EcologicalStatus	ECO_STAT	According to Annex V		1	Mandatory {H = High G = Good P = Poor B = Bad}
EcologicalPotential		According to Annex V	String		Mandatory for artificial / modified {H = High

Attribute	FieldName	Definition	Type	Length	Restrictions
					G = Good M = Moderate P = Poor B = Bad}
NonCompliant		Annex V 1.4.2(iii) – whether the water body does not comply with environmental quality standards	String	1	N = Non-Compliant}
ChemicalStatus	CHEM_STAT	According to Annex V		1	{G = Good F = Failing}

TransitionalWaters

Attribute	FieldName	Definition	Type	Length	Restrictions
	SHAPE	Geometry (polygons)	Geometry		Mandatory
	EU_CD	Unique code for a waterbody at EU level	String		Mandatory. As per coding guidelines
	NAME	Locally used name	String	100	Mandatory
MSCode	MS_CD	Unique code for a waterbody within MS		22	As per coding guidelines
EcoRegionCode	REGION_CD	Ecoregion to which a waterbody belongs	String	2	Mandatory. Foreign Key to REGION_CD in EcoRegion
System	SYSTEM	Type of characterization of a waterbody	String		Mandatory {A, B}
InsertedWhen	INS_WHEN	Moment of insertion in the database	Date	YYYYMMDD	Mandatory
InsertedBy		Acronym of operator	String		Mandatory
RiverBasinCode	BASIN_CD	The code of the parent river basin (see coding system)	String		Mandatory. Foreign Key to EU_CD in RiverBasin
StatusYear	STATUS_YR	reporting of waterbody characterisation	String	4	Possibly can be dropped if duplicates INS_WHEN
HeavilyModified	MODIFIED	Whether the waterbody is heavily modified	String	1	Mandatory {Y, N}
Artificial	ARTIFICIAL	Whether the waterbody is artificial	String		Mandatory {Y,N}

Attribute	FieldName	Definition	Type	Length	Restrictions
SalinityTypology	SALINITY	Salinity category according to Annex II	String	1	Mandatory {F = Freshwater M = Mesohaline P = Polyhaline E = Euhaline}
	TIDAL	category according to Annex II	String		Mandatory {MICRO, MESO,MACRO}
Latitude	LAT	Definition not given in WFD. Assume Latitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Can be calculated from supplied geometry
Longitude	LON	Definition not given in WFD. Assume Longitude (in ETRS89) of mathematical centre of waterbody	Number	8,5	Can be calculated from supplied geometry
Depth	DEPTH				
CurrentVelocity	VELOCITY	Not defined			Optional
	WAV_EXPO	Not defined			Optional
ResidenceTime	RES_TIME	Not defined			Optional
MeanWaterTemp	AV_W_TEMP	Not defined			Optional
MixingCharac	MIXING				Optional
Turbidity		Not defined			
MeanSubstratComp		Not defined			Optional
ShapeCharacter		Not defined			
WaterTempRange	W_TEMP_RGE	Not defined			

Appendix IV: Unique Identification Coding Systems

1. Introduction

Many existing river coding systems were reviewed, these are documented at http://193.178.1.168/River_Coding_Review.htm. The historic attention to rivers was driven by the need to assign structure when identifying stream orders and nested sub-catchments. Other feature coding is more straightforward and has been largely ad-hoc.

Recommendations are going to upset established practices for most Member States. The benefits however necessitate that this task be undertaken. The Water Framework Directive demands that we manage and share environment data across national borders. At the core of this is the need to have a common approach to the way we reference components of the observed and managed environment.

The primary objective is to agree unique identification codes, which are harmonised internationally especially in the context of international river basins. The INSPIRE principles are considered with respect to the maintenance of codes by those who can do so most efficiently. Automated coding is also supported where appropriate with the objective of providing unique codes across numerous elements. Automation would in some instances also provide smart codes, which carry additional information about topological connectivity.

A common coding system will a) greatly facilitate the sharing of data across borders, b) form a framework for EU reporting and c) enable efficient electronic reporting at national and EU levels. Any other approach would merely put off the inevitable efficient structure that must evolve. Hopefully by acting now we can realise the benefits early at this crucial stage of implementation of the Water Framework Directive.

2. Required Coding Structure

2.1 Levels of unique identification coding

A. At the highest level, water bodies and river networks need to be identified;
B. These elements may need to be sub-divided. This cannot be fully predicted, as it may arise at a later date due to changes in ecological or physical boundaries. Thus, sub-division coding must not interfere with established primary coding;
C. Status monitoring, pressures and impacts are usually intrinsically linked to water bodies and thus may be developed as extensions of water body coding;
D. Diffused pressures are likely to be linked to many water bodies. Hence, they must be identified with their own codes and related back to water bodies through database links.

2.2 Coding Strategy

The proposed coding structure must adhere to the following:

1. Generation of unique European codes;
2. Establishment and maintenance of codes by those who can do so most efficiently.

It should also addresses the following important issues:

3. Generation of harmonised RBD and European codes where possible;
4. The use of codes that directly carry information, where possible and convenient, particularly where coding is automated. *(Such information can be used to a) directly determine hydrological connectivity, b) validate data and c) determine the organisations responsible for code maintenance.)*

Code maintenance is important and codes must be maintainable in a flexible way by a variety of independent organisations.

3. Local Spatial Features

These include pressures, status and impact monitoring and some water bodies. For example, municipal discharges, industrial discharges, agricultural pressures, groundwater abstraction points, coastal water bodies, etc. These features are generally identified and coded at a very local level and they lends themselves to the INSPIRE principle of data maintenance at one location and by those who can most efficiently do so. While feature codes are not strictly spatial data, but rather data tags, the same principle can be applied.

The recommended approach is:

1. Each Member States is uniquely identified by a 2-character code in accordance with ISO 3166-1-Alpha-2 codes;
2. Each MS, uniquely identifies the agencies or authorities, which manage or monitor local features. (For monitoring stations, the agencies of concern are those that establish them; other agencies may use these stations.
3. Local agencies or authorities assign, to features or monitoring stations, codes that are unique within local administrative areas;
4. Unique European codes are then generated by concatenating the above three elements.

Where there is only one organisation involved in the identification of particular features across the Member State, then step 2 above, identifying the coding agency, can be omitted.

In general a 4-digit code is recommended to identify coding authorities, features and monitoring stations. This can be split into a pair of 2 digit codes to represent local hierarchies and to enable infilling. However, Member States can use any feature coding structures required locally, provided:

- codes have a 2 character header attached prior to reporting at EU levels, which identifies the Member State, in accordance with ISO 3166-1-Alpha-2 country codes;
- the overall identification code does not exceed 24 characters (including the 2 character MS code);
- each identification codes generated is unique within the Member State.

4. Features with Hydrological Connectivity

Rivers are the primary example here, where gravity produces hydrological connectivity and flow direction. The extent of connectivity can reach across multiple Member States. Lakes, coastal waters and transitional waters are hydrologically connected through river networks. Hence it is wise to address rivers at the outset.

4.1 River Coding Approach

If rivers are already substantially identified, it may be pragmatic to extend existing coding. However, the number of additional rivers may amount to multiples of the number already coded. Also, codes may need to be reviewed for harmonisation with adjacent Member States.

River identification is likely to be computer-based. Coding could be as simple as sequential identifiers; however, structured hydrological codes are recommended. This enables rapid manual or automated analyses without the need to refer to GIS. The hierarchical nature of river structures lends itself to systematic nested coding. By using the same coding methodology at each tributary level, we can automatically determine codes and infer river connectivity.

A modified Pfafstetter system is recommended in the absence of alternative hydrological codes. The Pfafstetter system will need to be explored further to see if lakes can be better incorporated. Thus there may be further recommendations regarding its modification or replacement. For now, it is recommended on an interim basis and provides a mechanism to uniquely code river segments while also encapsulating river hydrological structures. Other hydrological coding or non-hydrological coding can be used, provided it uses unique identification codes, of lengths up to 22 characters. Codes of less than 22 characters should not be padded out with leading zeros (‘0’) for readability and to minimise data entry keying errors.

Both hydrological and non-hydrological identification codes should be preceded by two character codes to uniquely identify the Member State that assigned them.

4.2 River Coding

The main document explains the **MS MW N_1 N_2 N_3 N_4, …** code structure along with Modified Pfafstetter coding**.** Together the MW (Marine Waters) and N_1 N_2 N_3 N_4, … (river segment) components can provide unique hydrologically structured codes that integrate all surface water bodies. Alternatively these components can be replaced by any code not exceeding 22 characters.

4.3 River Coding - Practical Implementation Issues

4.3.1 Trans-boundary River Coding

Where Member States wish to co-operate in the generation of unique codes for trans-boundary rivers, the Pfafstetter system can be used. The highest level Pfafstetter code(s) could be established by the Member State with the coastal outlet. This will reserve the initial digit(s) for coding within each involved Member States, particularly along the main channel. More detailed coding can then be immediately undertaken in the border regions. Each Member State can then proceed with local detailed coding, at their own pace; yet when complete, the full catchment will be coded in a manner that enables hydrological connectivity to be ascertained.

The Pfafstetter approach can be used even where an adjacent Member State wishes to adopt a different coding practice. For example, downstream borders can be considered as marine borders. Catchment contributions from an upstream Member State can be assumed to come from a simplified catchment topology. Regardless of which approach is taken, there will always be a need to agree coding strategies along border regions.

4.3.2 Multiple Harmonisation Agreements

River identification coding may require independent harmonisation with different neighbouring Member States. Care is needed to ensure that multiple harmonisation agreements do not introduce the possibility of non-unique identifiers across different RBDs within the Member State. A number of options are available in this regard:

- A pan European or pan Member State river identifier coding system might be initially developed giving unique codes to all major rivers;
- Unique codes might be assured by the use of the MW code, a marine waters identifiers in accordance with the International Hydrographic Organisation delineation[1], with possible further local subdivisions per regional marine agreements;
- Where rivers drain into the same marine waters, the MS and MW header codes might be immediately followed by the coastal water outlet Member State code.

4.3.3 Impact of Lakes on River Codes

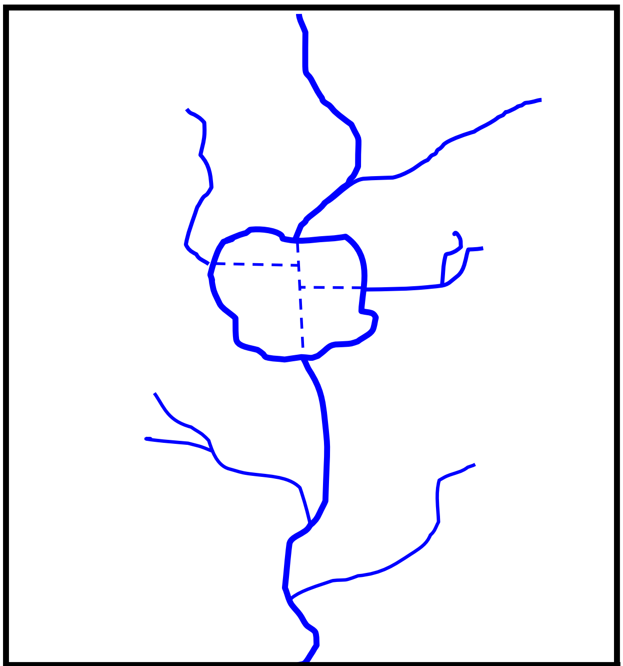


Fig.1. The network is connected manually through the lake. For simple lakes this could be straight lines joining the main channel to the lake tributaries.

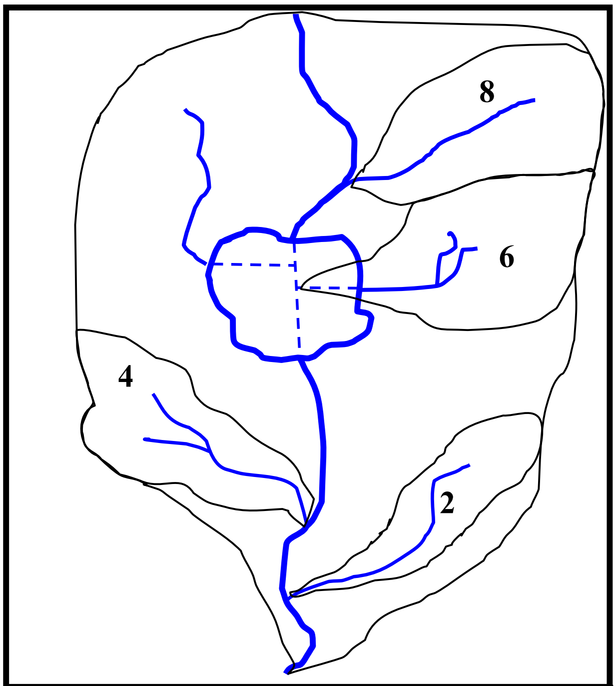


Fig. 2. The major tributaries are identified, while ignoring the presence of the lake.

The easiest way to code river reaches and their basins through lakes is to visualise lakes as wide river channels. This is presented in the Figures 1 and 2.

The river network is connected by simple line-work through the lake. For long curved lakes more extensive line-work is needed. The JRC and various Member States have achieved this with semi-manual procedures. The main tributaries of the resulting network are then coded.

By using a digital elevation model, and effectively ignoring the presence of the lake, we can determine how the sub basin boundaries cross the lake. Interpolation, between the elevation at the imaginary confluence and elevations outside of the lake, will generate a very slightly sloped surface, across the lake, draining towards the imaginary confluence. The lines of steepest gradient will then determine the imaginary watersheds across the lake.

The above method is reliant only on a digitised river network and on a digital elevation model to determine river coding. An undesirable result is that tributary catchments do not enter lakes at a point. This can be seen in Fig. 3 for tributary catchment '6'.

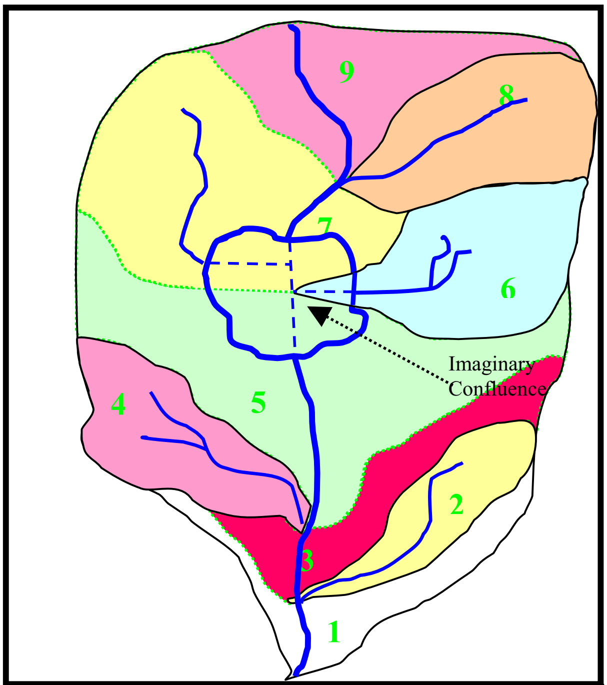


Fig. 3. The inter-basins are identified. Inter-basin boundaries meet, and cross, the lake at points determined by elevation model interpolation (e.g. basins 5 and 7)

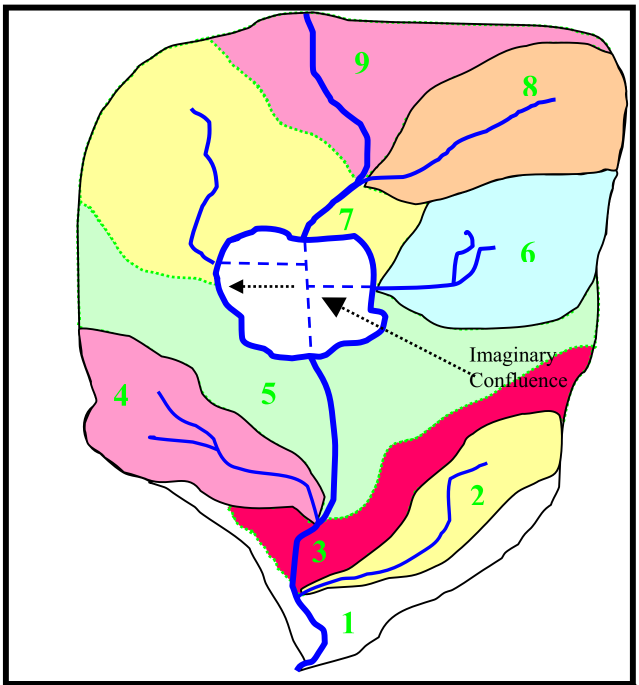
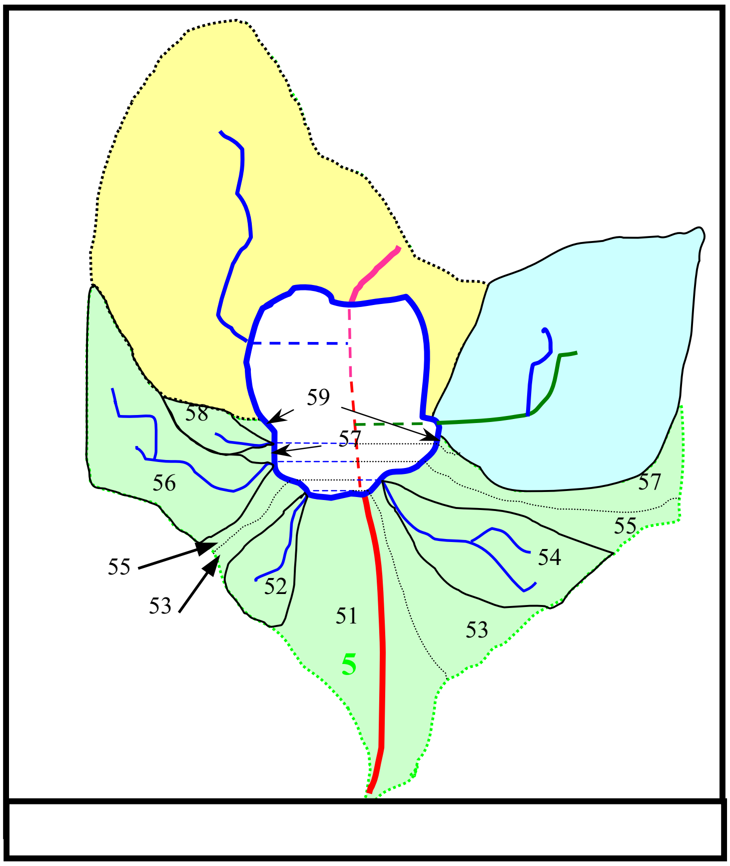


Fig. 4. Alternative approach to tributary catchment 06. Inter-basin boundaries meet the lake at a points determined by elevation model interpolation (e.g. basins 5 and 7).

An alternative approach, which takes lakes into account, is shown in Figure 4. This method determines tributary catchments from the tributary and lakeshore intersection. The inter-basin catchments are determined as before, but are truncated at the lakeshore. This approach lends itself better to subsequent further levels of coding of smaller tributaries along the lakeshore and provides a better hydrological breakdown. It is thus the recommended approach.

To proceed with further levels of river coding, the lakeshore can be treated as though it was the river bank of a rather wide main channel. Thus the major tributaries are identified in the inter-basins and a new level of sub-basins and sub-inter-basins is established.

As this process progresses, while tributaries will be neatly identified, inter-basin codes will refer to pairs of disjointed lake shorelines. See Fig. 5.



Hence the inter-basin codes are not suitable for identifying lakeshores, and an independent parallel coding system is needed for that purpose. The system also splits lake-inter-basins, odd numbered catchments in Fig. 5. Tributaries draining into the lake are however coded in a hydrologically sound manner, as can be seen in Fig. 5 for even numbered catchments. Along with the main river channel, these tributaries will generally be the main source of inputs to lakes.

4.3.4 General Anomalies in River Identification Coding

Rivers may disappear into underground systems. The larger flow at a confluence may not come from the upstream contributing catchment with the largest surface area. These and other anomalies will require some level of manual intervention to aid what would otherwise be a largely automated coding process.

4.3.5 Testing the Pfafstetter Coding System

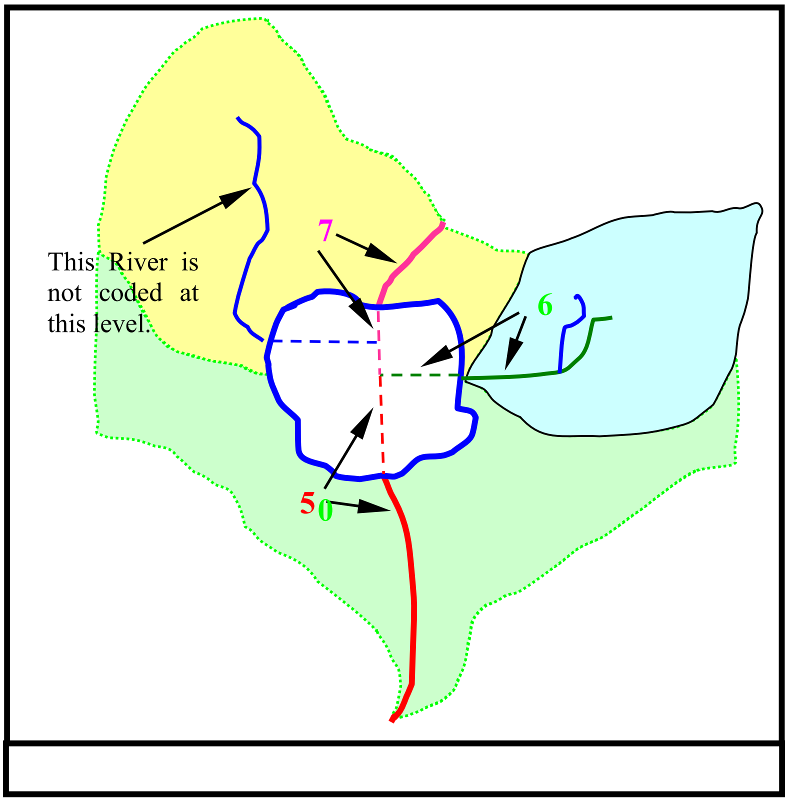
The JRC generated Pfafstetter codes across all of Europe in the prototype GIS. First river channels were identified from digital elevation models. Existing vector maps were used to automatically improve interpolation in flatter regions and to determine lake boundaries. River channels were connected through lakes. The codes generated were in general 6 digits long or less.

5. Lakes

5.1. Lake Coding

River reaches, or continua (imaginary reaches), within lakes, can be coded in the normal manner. A lake will typically be associated with many river reaches (real and imaginary). Fig. 6 demonstrates river codes generated around a lake. At this initial level of coding, there are 3 river reaches involved and the lake intersects each. As rivers and lakes will not usually meet at a drainage catchment boundary, we will not get neat inclusive relationships.

We need to select one code to uniquely represent the lake. The downstream reach code is a suitable candidate for this, as we already know that it is unique. In addition this reach is subject to all lake inputs. Thus, where hydrological river coding is deployed, the use of the downstream river reach code would also provide a degree of hydrological information to lake codes. Numeric upstream / downstream Pfafstetter tests could then be applied.



Shorelines could be identified by a further 2-digit code where even numbers identify the left bank and odd numbers identify the right bank. If additional subdivision is required, then an additional pair of digits can be added. These codes would be assigned manually, to identify administrative, hydrological, ecological and other boundaries. Intervals may be left to facilitate further subdivisions.

An alternative coding structure could be used for lakes and shorelines. Ideally the uniqueness of new lake or shoreline codes should be immediately visible to the person assigning them. Thus extensions of river network coding and the use of sequential identifies are desirable, with allowance for intervals within the sequence.

In summary then:

- Lake codes could use the same format as river inter-basin codes, e.g. '51' in the case of Pfafstetter coding in Fig. 6;
- Hydrological connectivity could be determined directly from lake codes if we use the downstream Pfafstetter or other hydrological river code;
- Lakeshores should use a sequential code format with allowance for later sub-division, such as 2 pairs of digits, e.g. 51-10/00;
- An objective should be to make uniqueness readily visible.

5.2. Dealing with Lake Anomalies

We may encounter:

1. Lakes which have no river outlet;
2. Lakes whose existence or extents are seasonal;
3. A number of small lakes of surface area >0.5 km^2 along a river of catchment size just greater than $10km^2$;
4. Other special cases.

These exceptions will require manual intervention to assign reasonable unique codes. In the event that the anomalies are too numerous to achieve this, then use a simple system assigned code (e.g. a unique integer within a RBD or a hydrological area).

6. Transitional Water Bodies

The recommended river coding system will extend to marine waters and will maintain hydrological connectivity relationships. Those river reaches, which are wholly within the transitional waters area, can be assigned database attribute values to identify them as transitional. Around the transitional water body periphery, there will be river reaches, which are partially within transitional waters. Thus, we must rely on database attributes combined with GIS queries to identify the portions of river reaches that lie within transitional water bodies. And hence we can find no inclusive coding system that links directly with river coding.

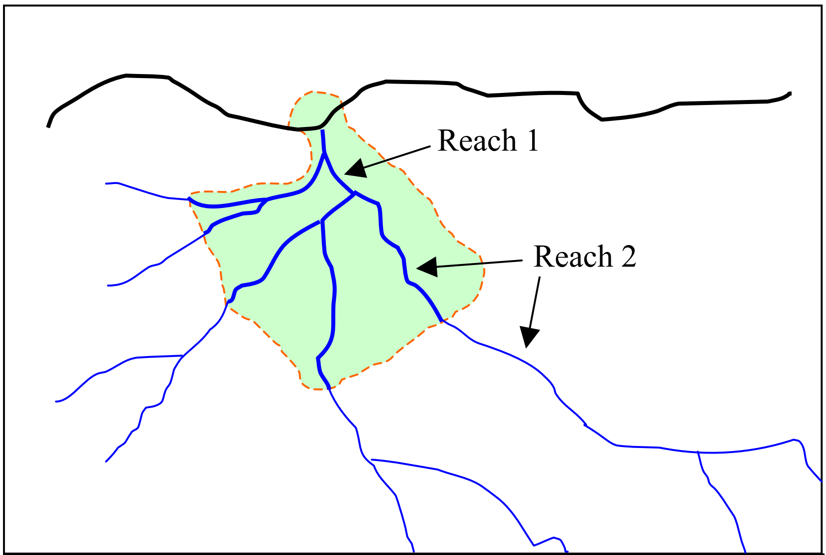


Figure 7. Rivers reaches wholly or partially in Transitional Waters

We can assign some hydrological intelligence to the transitional waters water body code if we use the down stream (outlet) river reach code as the code for the transitional water body. We can thus readily determine the upstream river catchments and lakes, which contribute to the freshwater inputs by referring to codes alone.

7. Coastal Water Bodies

As discussed under river coding sections, unique identifiers for marine waters can be provided internationally by using identifiers in accordance with the International Hydrographic Organisation delineation, with possible further local subdivisions per regional marine agreements. This area needs to be considered in conjunction with the findings of working groups concerned with the typology and classification of transitional and coastal waters.

8. Groundwater Bodies

The following code for **groundwater bodies** are recommended:

- a 2 character Member State Code (ISO 3166);
- an up to 22 character Groundwater Body code.

According to the WFD, groundwater bodies can be classified as single GW-bodies or as a group of GW-bodies. Furthermore GW-bodies can be classified as shallow or deep bodies, the definition of which is still under discussion.

GW-bodies might be divided into sub-bodies for several reasons. The WFD WG 2.8 "Guidance on tools for the assessment and classification of groundwater" has recommended the division of GW-bodies in sub-bodies for statistical purpose. Within the guidance paper, a criterion for monitoring networks is proposed and if the criterion is not fulfilled the monitoring network has to be adapted accordingly or the GW-body has to be sub-divided (http://www.wfdgw.net/).

WG 2.8 also developed a coding system for GW-bodies and sub-bodies. This system suits the statistical tool that was developed for the assessment and classification of groundwater. Within this tool GW-bodies and sub-bodies have different codes and can be addressed separately. Use of this system for GIS coding of GW-bodies would cause problems because the unique code for each polygon is made from two codes that are stored separately. A new unique code for each polygon would have to be introduced and as a consequence three codes would have to be maintained.

In future it might then be necessary to introduce a new code for trans-boundary GW-bodies to be able to assess the total body irrespective of Member State borders.

When assigning GW-bodies to river basins, the borders of river basins may not fit the borders of GW-bodies. The assignment of GW-bodies to river basins can only partly be done geographically. In many cases the assignment will be an administrative decision, handled within a database and will not be geographically reconstructable.

The above issues argue for a simple GW-body code as recommended and a more complex database solution with high flexibility.

9. Sub-Division of Primary Codes

9.1 Division of Rivers and Catchments

After identifying the river reaches that define the topology of the river, it will be necessary to subdivide these reaches for local management purposes. This subdivision will be necessary for river quality monitoring stations, industrial discharge points, ecological boundaries and physical boundaries such as those caused by weirs and changes in river channel geometry. This subdivision is going to be accomplished by manual means.

The need for common standards is determined by the needs for EU reporting but maybe more so by the needs of international RBDs. For example, we may want to divide a first order, and hence long, river reach into sections determined by water quality monitoring points or by sections upstream and downstream of major discharges or urban centres. As this is going to be largely a manual process, it is best to keep the coding simple and extendable.

The recommended approach is to use 2 pairs of digits. The first pair will enable up to 99 initial subdivisions of the reach. The second level would allow further break down of these at a later date. Intervals can be left to allow additional inputs. For example, the first upstream stretch on a reach might be numbered 10/00, the second 20/00. If necessary, the first section could be later subdivided at the top level by introducing 05/00. Lower level subdivision can be achieved by use of the second digit pair, e.g. 10/10, 10/20, 10/30, etc.

Thus if the river reach has a Pfafstetter code of 57, and a section on it is identified as 10/10, then the full section code is given by 57-10/10.

Practised variations on this approach include the use of upstream distance. This has the benefit of providing exact location. It has the disadvantage of requiring prior distance analyses and GIS can maintain location in any regard.

Which approach to take is a matter for individual Member States to decide upon. It is very dependent of the capabilities and structures of code management organisations. The primary objective must be to provide a mechanism for manual assignment of identification codes that allows immediate assurance of uniqueness by visual inspection.

When sharing GIS data, these sections should be provided as GIS line-work with this code attached to each element as its identifier.

9.2. Division of Lakes, Coastal, Ground & Transitional Waters

9.2.1. Division of Lakes

Subdivision of lakeshores has been discussed in Section 6.1. Lake regions, such as bays, etc, might be coded in a similar fashion, using initially 2 digits with a further 2 digits for subdivisions at a later date.

If '51' is a lake identifier, then:

- Lakeshores could use a format such as 2 pairs of digits, e.g. 51-10/00;
- Lake sub-regions could use a format such as 2 pairs of digits, e.g. 51-12/00.

Again, any unique coding mechanism can be adopted by Member States, but is strongly recommended that codes be easily reviewed visually.

When sharing GIS data, lakeshores and lake sub-regions should be provided as GIS line-work with this code attached to each element as its identifier.

9.2.2. Division of Coastal, Transitional & Groundwaters

Division of Coastal, Transitional and Ground Waters could take the same approach of assigning 2 pairs of digits, which allows for further sub-division. Any unique coding mechanism can be adopted by Member States, but is strongly recommended that codes be easily reviewed visually.

10. Pressures, Status and Impacts

10.1. Introduction

10.1.1. Coding Structure

This Section particularly lends itself to approach outlined in Section 3 'Local Spatial Features'. Hence unique European codes are generated by concatenating:

- a 2-character unique Member States code;
- a unique identifier for the local coding authority;
- a unique code for the feature administered by that coding authority.

10.1.2. The Impact of Laboratory Information Systems

All monitoring data is going to be processed through laboratory data management systems. Such databases are going to merge river monitoring samples with drinking water, bathing, landfill, lake, ground water, treatment plant, industrial discharge and other sample data. All samples taken are going to enter such databases in sequential order as they arrive at the laboratory. For feature codes to remain unique, within laboratory databases, it will be necessary to also identify the sample type.

The focus of such laboratory systems is on the laboratory process and not on the subsequent usage or ordering of the data. Sample type codes will also aid the subsequent separation of data into its GIS topics.

These additional sample type codes should be maintained within laboratory systems only, in an additional field alongside the feature coding field. To keep codes simple within GIS, it is not proposed that these laboratory tags be appended to proposed GIS codes.

For example, a river station would have a laboratory code such as 'RS'. This will be used to identify the type of sampling station at which the sample was taken. This will ease data displays, data reporting and data exports. But most of all, it will greatly assist electronic data transfer associated with the extensive pools of data that exist in laboratory systems.

It must be appreciated that such laboratory systems will be the data engines for much of the subsequent GIS thematics. Hence, we need to put in place practices that will ease the data flows to and from such systems. To do this, we need to identify the laboratory codes that will achieve this. Recommended laboratory codes are listed below.

10.1.3. Laboratory System Supplementary Codes

The following codes are suggested as possible identifiers within laboratory systems. These are database attributes, rather than identification codes, but they are required in combination with monitoring station codes for unique identification within laboratory system. They would thus provide a standard approach for direct access to such data from GIS.

'RS' for river stations.
'*LS*' for lake stations.
'CS' for coastal stations.
'TS' for transitional water stations.
'GW' for ground water stations.
'DW' for Drinking Water along with
  'GWA' to indicate Ground Water Abstraction, or
  'SWA' to indicate Surface Water Abstraction.
'BP' for bathing water stations.
'PI' for pollution incident samples.
'*DP*' refers to a sample taken at a Discharge Point (effluent). For monitoring of receiving waters at *Upstream* and *Downstream* locations, this should be replaced by '*DU*' and '*DD*' respectively. 'DP', 'DU' or 'DD' should be combined with
  '*IND*' to indicate an Industrial discharge, or
  '*COM*' for a Commercial discharge, or
  '*INS*' for a Institutional discharge, or
  'AGR' for an Agricultural discharge, or
  'PAV' for a Paved area discharge, or
  'CSO' for a Combined Sewer Overflow, or
  'WWT' for a Wastewater Treatment plant discharge, or
  'WSP' for a Water Supply Plant discharge, or
  'LFL' for Landfill Leachate.

10.2. Water Body Monitoring Stations

Transitional or Lake water body monitoring stations identification codes might be simple extensions to the overall water body code or the codes for the river segments that occupy the transitional water body. Either method will provide a mechanism for quick assignment of unique codes at a local level.

Thus if an Irish river stretch is identified as IE5441, and a station on that by 03/00, then the full station code is given by:

IE54410300.

In the example shown in Fig. 8., the transitional water body code would be '541'. Monitoring stations could be an extension of the water body code, '541'. Alternatively, as shown, they might be extensions of the river segment codes.

In laboratory databases, the code or attribute 'TS' (transitional station) might be associated with the code 'IE54410300' and 'RS' with 'IE5410450'.

Otherwise, monitoring stations might gain their unique identification codes as extensions of identification codes for local code assigning authorities. Other practical approaches to unique code maintenance may be possible. Visual confirmation of uniqueness and flexibility for all involved organisations should be incorporated into whatever approach is adopted.

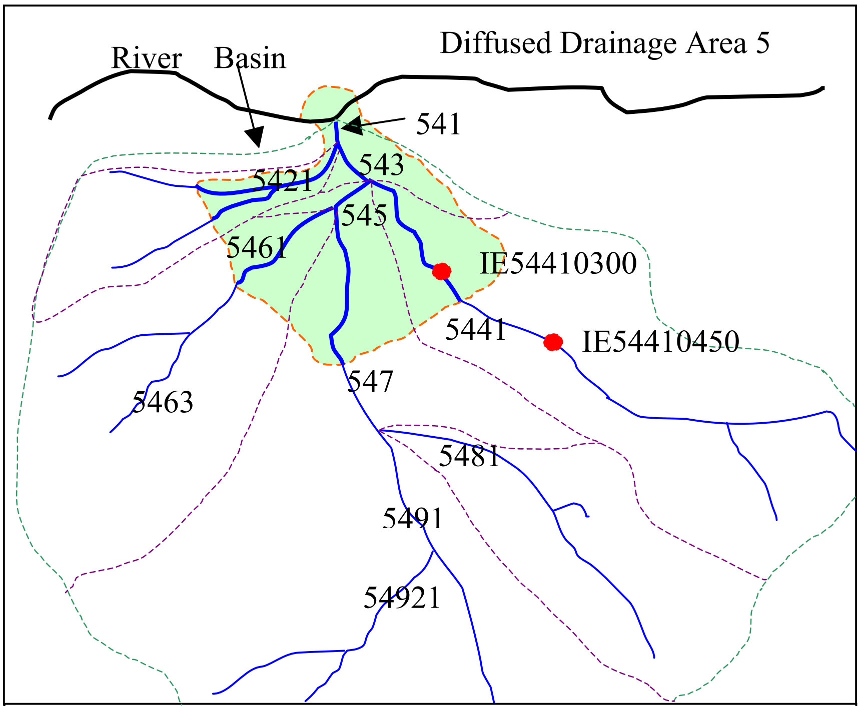


Figure 8. Rivers reaches wholly or partially in Transitional Waters

11. Introducing River Basin Districts

RBD competent authorities are not going to take on the regulatory functions of existing agencies. Thus other agencies are going to remain the primary source of feature identification. Hence it may cause confusion to try to introduce RBDs into the unique codes to be generated. It is suggested that the relevant RBD be identified through database fields and GIS.

12. Working within a Member State

Obviously the Member State component of codes, i.e. 'MS', can be dropped when using data at a local level, provided this information is added on to codes when required to be unique at a European level.

13. Additional Features

The chapter outlining recommended GIS layers identifies additional layers. These include administrative areas, background mapping and protected areas. These are covered by the general rule of supplying codes in the MS$\#_1\#_2\ldots\#_{22}$ format.

Protected areas layers are addressed by Natura 2000 which uses a two character Member State identification code followed by a 7-character code to identify SCI's (Sites of Community Importance) and SPA's (Special Protection Areas) within a Member State.

14. ISO 3166-1-Alpha-2 Country Names and Code Elements

The latest list can be acquired at:

http://www.din.de/gremien/nas/nabd/iso3166ma/codlstp1/en_listp1.html

Once feature codes are assigned, codes should not change. Hence, new country names and country codes should only impact on future feature coding. However, alternative arrangements may be agreed with adjacent Member States and the Commission.

Appendix V: Detailed Specifications for Data Validation

Form for data quality description

Data quality component	Short Name	Component Domain
Scope	DQ_Scope	Free text
Element	DQ_Element	Enumerated domain 1-Completeness 2-Logical consistency 3-Positional accuracy
Subelement	DQ_Subelement	Enumerated domain: Completeness 1-Commission 2-Omission Logical Consistency 1-Conceptual consistency 2-Domain consistency 3-Format consistency 4-Topological consistency Positional accuracy 1-Absolute accuracy
Measure[13]	DQ_Measure	
Measurement Description	DQ_MeasureDesc	Free text
Measurement ID	DQ_MeasureID	Enumerated domain
Evaluation Method	DQ_EvalMethod	
Type	DQ_EvalMethodType	Enumerated domain 1-internal (direct) 2-external (direct) 3-indirect
Description	DQ_EvalMethodDesc	Free text or citation
Quality Result	DQ_QualityResult	
Value Type	DQ_ValueType	Enumerated domain 1-Boolean variable 2-number 3-ratio 4-percentage 5-sample 6-table 7-binary image 8-matrix 9-citation 10-free text 11-other
Value	DQ_Value	Record
Value Unit	DQ_ValueUnit	(depends on data quality value type)
Date	DQ_Date	ISO conform
Conformance Level	DQ_ConformanceLevel	Value or set of values

[13] Abstract classes are indicated italic characters.

Topological rules for GIS layers

River basins

must not overlap
must not have gaps
must be covered by extent of river basin districts
must not overlap with coastal waters
must not overlap with transitional waters
boundary must be covered by river sub basins
must cover features of river sub basins
must contain at least one river
must touch the coastline

River sub-basins

must not overlap
must not have gaps
must be covered by extent of river basin districts
must not overlap with coastal waters
must not overlap with transitional waters
must contain at least one river

River basin districts

must not overlap
must not have gaps
must cover features of river basins, surface water bodies, groundwater bodies, monitoring stations

Districts of competent authority

must not overlap
must not have gaps
must cover features of basin districts

(Main) Rivers

must not have dangles (exceptions are sources and mouths)
must not overlap
must not intersect (nodes at intersections)
must not touch interior
must be covered by boundary of river basins
mouths must touch river basin boundaries
must not overlap with coastal waters, transitional waters
must not intersect with river (sub) basins (nodes at intersections)
outlet of each feature must touch coastline

Lakes

must not overlap
must not overlap with coastal waters, transitional waters
must be covered by districts of competent authority, river basin districts

Transitional waters

must not overlap
must not overlap with coastal waters, rivers, lakes, river basins
must be covered by districts of competent authority, river basin districts

Coastal waters

must not overlap
must not overlap with transitional waters, rivers, lakes
must be covered by districts of competent authority, river basin districts
must touch transitional waters, river basins

Groundwater bodies

must be covered by districts of competent authorities, river basin districts

Monitoring stations

must be covered by area of districts of competent authorities, river basin districts

National boundaries on land and coastlines

must cover features of national delivery of river basins
boundary must be covered by national delivery of river basins

Examples of reporting data quality according to ISO 19115

Quantitative quality information

Data quality component	Value	Description
dqSope[14]		
scpLvl	009	feature
scpExt		Info on geographical extent
geoEle		
exTypeCode	1	inclusion
GeoDesc		
geoid		
code	France	
or *GeoDesc*		
BoundPoly		
polygon	x0,y0,x1,y1,…,xN-1,yN-1,x0,y0	
or *Geodesc*		
GeoBndBox		
westBL	-10	
eastBL	7	
southBL	38	
northBL	55	
scpLvlDesc		
featSet	river confluences, mouths	
dqReport		
DQAbsExtPosAcc		Positional accuracy, absolute external
measName	Positional Accuracy of nodes in river network	
measDesc	Horizontal positional accuracy at 95% confidence level	
evalMethType	2	directExternal
evalMethDesc	Divide area into 4 segments. Draw a proportional sample of a total of 20 nodes. For each of the selected nodes, measure the error distance between absolute co-ordinate values of the node in the dataset and those in the IMAGE2000 dataset (universe of discourse). Compute the RMSE (Root Mean Square Error) and the horizontal positional accuracy from the RMSE. see: http://www.fgdc.gov/standards/status/sub1_3.html	
evalProc	Federal Geographic Data Committee	
measDateTime	2002-06-07	
measResult		
QuanResult		
quanvalType	number	
quanValUnit	metre	
quanVal	30	

[14] Abstract classes are indicated italic characters.

Data quality information	Value	Description
dqScope		
scpLvl	005	dataset
scpExt		Info on geographical extent
geoEle		
exTypeCode	1	inclusion
GeoDesc		
geoid		
code	EU	
GeoDesc		
BoundPoly		
polygon	x0,y0,x1,y1,…,xN-1,yN-1,x0,y0	
Geodesc		
GeoBndBox		
westBL	-30	
eastBL	35	
southBL	32	
northBL	72	
scpLvlDesc		
featSet	dataset	
dqReport		
DQCompOm		Completeness, Omission
measName	Missing water bodies	
measDesc	Number of water bodies missing	
evalMethType	2	directExternal
evalMethDesc	Select all inland water bodies in CLC dataset > 0.5 km^2 (universe of discourse) and verify existence of each select water body in the dataset. Count those water bodies, that are not present in the data set.	
measDateTime	2002-06-07	
measResult		
QuanResult		
quanvalType	number	
quanValUnit	features	
quanVal	20	
or ***dqReport***		
DQCompOm		Completeness, Omission
measName	Missing water bodies	
measDesc	Pass – Fail	
evalMethType	2	directExternal
evalMethDesc	Select all inland water bodies in CLC dataset > 0.5 km^2 (universe of discourse) and verify existence of each select water body in the dataset. Count those water bodies, that are not present in the data set.	
measDateTime	2002-06-07	
Result		
ConResult		
conSpec	Draft GIS data model	Citation
conExpl	All features shall be in the dataset	
conPass	1	0 = fail, 1 = pass

Non-quantitative data quality information

Data quality component	ShortName	Value
Purpose	idPurp	The Communes dataset is a general purpose geographic database for supporting different GIS applications of the European Commission.
Usage	specUsage	**Usage #1** Mapping of population statistics An important reason of the creation of the GISCO commune boundaries database is the use of these data in combination with the SIRE data in a Geographic Information System. Typical usage is the presentation of SIRE statistics in all kinds of maps. An illustrative example is the presentation of population statistics. **Usage #2** Structural Funds Another important usage of the GISCO commune boundaries database is the definition, validation, storage and monitoring of regions eligible for structural funding. In general complete municipalities are eligible, but in some cases they are only partly eligible. In Sweden, for example, a differentiation is made between the 'mainland' part of a municipality and the islands. Mainland and islands are eligible for different funds. Because in Sweden the original dataset of administrative boundaries did not include the islands explicitly, it is not possible to store and present eligibility for structural funds in a proper way only on the basis of administrative boundaries. **Usage #3** Degree of urbanisation Within the framework of the Labour Force Survey, municipalities are classified according to their 'degree of urbanisation'. Three classes of degree of urbanisation are defined on the basis of the algorithm below: densely populated, thinly populated and an intermediate class.
Lineage	dataLineage	**Source**: As a basis for the 1997 data set of the Commune boundaries for the European Union the SABE database of MEGRIN is used. The SABE database is compiled from official NGI sources. The source data are of the best available semantic quality and of the application scale the closest to 1:50,000 for each country. For the 1:1,000,000 scale coverage the 200 m resolution data from MEGRIN have been used. **Process Step**: Acquisition of SABE data sets. **Process Step**: Coding the CMFTTP **Process Step**: Structuring of data coverage according to overall database design requirements. - Integration of coastlines for SE, NO, FI, NL, HR, PL: Overlay the commune cover with the Scole (coastline). - Integration of lakes through an overlay of the commune cover with the lakes. - Topological quality. Sliver polygons were removed manually. Most sliver polygons were detected in those countries where the coastlines and lakes were integrated. **Process Step**: Appending all country coverages to one coverage. **Process Step**: Conversion to standard GISCO projection system: Lambert Azimuthal projection. **Process Step**: To make a unique coding the SHN code was combined with the country code, SHN = 031003 and ICC = PT makes CMRGCD97 = PT031003. Process Step: The NUTS 3 codes were filled with information from the NUEC1MV7 coverage. This was carried out by taking the commune points and overlaying them with the NUTS coverage. All points that

did not have a match with the NUTS coverage were removed. Then the point coverage was linked to the polygon coverage and the NUTS field in the polygon cover could be filled. All communes that did not have a NUTS code were coded manually. Lakes have been coded with 'LAK', e.g. in Italy lakes are coded 'ITLAK' as NUTS 3 code.

The CMRGCD could only be coded with NUTS level 5 codes for countries that have a link to the SIRE database. These are: AT, BE, DE, DK, ES, FI, IE, IT, LU, PT, SE. For all other countries the CMRGCD was coded with the lowest available NUTS code plus a number of X to fill the complete field.

The Eastern European countries were coded with NURGCD = 'EUCON' and CMRGCD = 'EU00000CON'. Lakes are coded according to the same principal 'EULAK' and 'EU00000LAK'. Within the Italian borders there are two communes that have been coded in a special way, i.e. the Vatican City (CMRGCD = VA00000CON) and San Marino (CMRGCD = SM00000CON).

Process Step: For those countries where a link exists to the SIRE database the name field (CMRGNM) could be filled with names from SIRE. For all other countries the name field has been filled with data provided with the SABE boundaries. These names are delivered as lower case and they contain special characters. According to the GISCO naming conventions the names had to be converted to UPPER case and all special characters were replaced with their **replace characters???**

Appendix VI: Reference System

ETRS89 Ellipsoidal Co-ordinate Reference System (*ETRS89*)

The European Terrestrial Reference System 1989 (ETRS89) is the geodetic datum for pan-European spatial data collection, storage and analysis. It is based on the GRS80 ellipsoid and is the basis for a co-ordinate reference system using ellipsoidal co-ordinates. The ETRS89 Ellipsoidal Co-ordinate Reference System (ETRS89) is recommended to express and to store positions, as far as possible.

Table 1 gives a full description of the ETRS89 Ellipsoidal Co-ordinate Reference System (ETRS89), following ISO 19111 Spatial Referencing by Co-ordinates.

Relationship between ellipsoidal and Cartesian co-ordinates

The co-ordinate lines of the ellipsoidal co-ordinate system are curvilinear lines on the surface of the ellipsoid. They are called parallels for constant latitude *(φ)* and meridians for constant longitude *(λ)*. When the ellipsoid is related to the shape of the Earth, the ellipsoidal co-ordinates are named geodetic co-ordinates. In some cases the term geographic co-ordinate system implies a geodetic co-ordinate system.

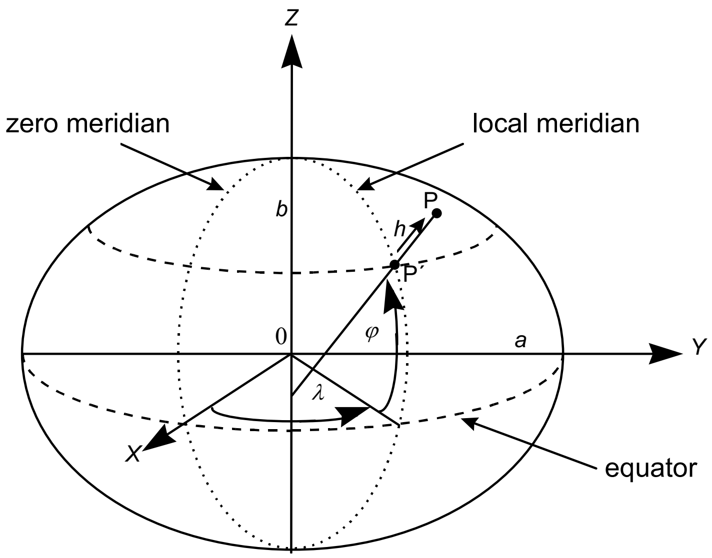


Figure 1 — Cartesian co-ordinates and ellipsoidal co-ordinates

If the origin of a right-handed Cartesian co-ordinate system coincides with the centre of the ellipsoid, the Cartesian *Z*-axis coincides with the axis of rotation of the ellipsoid and the positive *X*-axis passes through the point $\varphi = 0$, $\lambda = 0$.

Table 1 – ETRS89 Ellipsoidal Co-ordinate Reference System Description

Entity	Value
CRS ID	ETRS89
CRS alias	ETRS89 Ellipsoidal CRS
CRS valid area	Europe
CRS scope	Geodesy, Cartography, Geoinformation systems, Mapping
Datum ID	ETRS89
Datum alias	European Terrestrial Reference System 1989
Datum type	geodetic
Datum realization epoch	1989
Datum valid area	Europe / EUREF
Datum scope	European datum consistent with ITRS at the epoch 1989.0 and fixed to the stable part of the Eurasian continental plate for georeferencing of GIS and geokinematic tasks
Datum remarks	see Boucher, C., Altamimi, Z. (1992): The EUREF Terrestrial Reference System and its First Realizations. Veröffentlichungen der Bayerischen Kommission für die Internationale Erdmessung, Heft 52, München 1992, pages 205-213 or ftp://lareg.ensg.ign.fr/pub/euref/info/guidelines/
Prime meridian ID	Greenwich
Prime meridian Greenwich longitude	0°
Ellipsoid ID	GRS 80
Ellipsoid alias	New International
Ellipsoid semi-major axis	6 378 137 m
Ellipsoid shape	true
Ellipsoid inverse flattening	298.257222101
Ellipsoid remarks	see Moritz, H. (1988): Geodetic Reference System 1980. Bulletin Geodesique, The Geodesists Handbook, 1988, Internat. Union of Geodesy and Geophysics
Co-ordinate system ID	Ellipsoidal Co-ordinate System
Co-ordinate system type	geodetic
Co-ordinate system dimension	3
Co-ordinate system axis name	geodetic latitude
Co-ordinate system axis direction	North
Co-ordinate system axis unit identifier	degree
Co-ordinate system axis name	geodetic longitude
Co-ordinate system axis direction	East
Co-ordinate system axis unit identifier	degree
Co-ordinate system axis name	ellipsoidal height
Co-ordinate system axis direction	up
Co-ordinate system axis unit identifier	metre

Appendix VII: Detailed Specifications for Metadata

1. Main metadata standardisation initiatives

Metadata is the information and documentation, which makes data understandable and shareable for users over time (ISO 11179, Annex B). We can distinguish different types of Metadata of increasing detail: Metadata for Inventory (i.e. internal to an organisation), Metadata for Discovery (i.e. that is necessary for external users to know who has what data, where to find it, and how to access it), and Metadata for Use (i.e. a fuller description of an information resource that enables users to make a judgement about the relevance and fitness-for-purpose of the resource before accessing it).

At the time of writing this report, no international standard on metadata is available. The European Committee on Standardisation (CEN) Technical Committee 287 developed a pre-standard on GI metadata in 1997, and the Federal Geographic Data Committee (FGDC) in the USA works at a national level on GI metadata standards.

Based on the experience of various standardisation bodies, the International Standardisation Organisation (ISO) is developing in its Technical Committee 211 a family of standards related to geo-spatial information, including one for metadata, ISO 19115. The resolution of the 14th plenary assembly of ISO TC 211 (Bangkok, 24-25 May 2002) has stated that the ISO standard No. 19115 Geographic Information – Metadata will be kept in the status FDIS and the date of publishing this document was postponed to December 2002.

In addition to the standardisation activities described above, other initiatives have emerged that gained wide support. One is the Dublin Core (DC) international initiative. It is not intended specifically for GI but focuses on the Discovery aspect of metadata related to multimedia in general. It helps discover information resources across disciplinary or sectoral domains.

Another relevant standard is ISO/IEC 11179, *Information technology — Specification and standardisation of data elements*. ISO/IEC 11179 is an international standard for formally expressing the semantics of data elements in a consistent manner, and is used as a base for many other standards, including DIS 19115.

Some organisations have already started to implement metadata, either in a proprietary "standard", or by adopting the recommendations of some national or international consensus process. Examples are the pre-standard of CEN/TC287, or the GISCO data dictionary. It is therefore desirable that appropriate migration mechanisms are set-out that allow to convert existing metadata into ISO 19115. Existing conversion, also called "mapping", exists between CEN/TC287 metadata elements and ISO 19115 and Dublin Core elements.

Recently the EC, EFTA and the European Committee for Standardisation (CEN) agreed to finance a project that will lead to an official mapping between Dublin Core elements and those of ISO 19115 (GI Metadata). The work, which takes form as a CEN Workshop Agreement (CWA), will result in three deliverables: the mapping (a draft of which is expected to be available by December 2002), a Guidance Document, and a spatial application profile. More information is available from http://www.cenorm.be/isss.

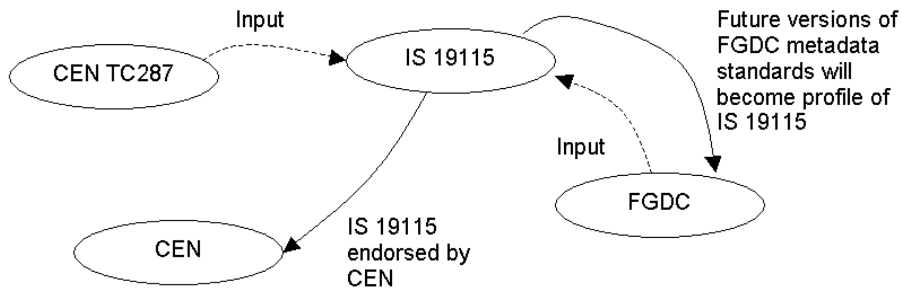


Figure 1: The CEN and FGDC (pre-)standards on metadata have given an important contribution to the creation of DIS 19115 (dashed lines).

No reference to Fig in text

2. ISO and the International Standard ISO 19115

ISO (the International Organisation for Standardisation) is a world-wide federation of national standards bodies (ISO member bodies). The International Standard ISO 19115 Geographic information - Metadata was prepared by Technical Committee ISO/TC 211: Geographic Information/Geomatics. ISO 19115, for example, highlights:

"*Digital geographic data is an attempt to model and describe the real world for use in computer analysis and graphic display of information. Any description of reality is always an abstraction, always partial, and always just one of many possible "views". This "view" or model of the real world is not an exact duplication; some things are approximated, others are simplified, and some things are ignored. There is seldom perfect, complete, and correct data. To ensure that data is not misused, the assumptions and limitations affecting the creation of data must be fully documented.*

Metadata allows a producer to describe a dataset fully so that users can understand the assumptions and limitations and evaluate the dataset's applicability for their intended use.

As geographic data producers and users handle more and more data, proper documentation will provide them with a keener knowledge of their holdings and will allow them to better manage data production, storage, updating, and reuse". (ISO 19115).

The creation of standard Metadata will:

- *"Provide data producers with appropriate information to characterise their geographic data properly.*
- *Facilitate the organisation and management of metadata for geographic data.*
- *Enable users to apply geographic data in the most efficient way by knowing its basic characteristics.*
- *Facilitate data discovery, retrieval and reuse. Users will be better able to locate, access, evaluate, purchase and utilise geographic data.*
- *Enable users to determine whether geographic data in a holding will be of use to them.*

This International Standard ISO 19115 defines general-purpose metadata, in the field of geographic information." (ISO 19115).

3. Scope of ISO 19115

The ISO 19115 defines the schema required for describing geographic information and services. It provides information about the identification, the extent, the quality, the spatial and temporal schema, spatial reference, and distribution of digital geographic data.

This International Standard is applicable to:

- the cataloguing of datasets, clearinghouse activities, and the full description of datasets;
- geographic datasets, dataset series, and individual geographic features and feature properties.

This International Standard defines:

- mandatory and conditional metadata sections, metadata entities, and metadata elements;
- the minimum set of metadata required to serve the full range of metadata applications (data discovery, determining data fitness for use, data access, data transfer, and use of digital data);
- optional metadata elements – to allow for a more extensive standard description of geographic data, if required;
- a method for extending metadata to fit specialised needs.

Though this International Standard is applicable to digital data, its principles can be extended to many other forms of geographic data such as maps, charts, and textual documents as well as non-geographic data.

4. Terms and definitions

data type	specification of the legal value domain and legal operations allowed on values in this domain *EXAMPLE:* Integer, Real, Boolean, String, Date, and SG_Point *NOTE:* A data type is identified by a term, e.g. Integer
dataset	identifiable collection of data *NOTE:* A dataset may be a smaller grouping of data which, though limited by some constraint such as spatial extent or feature type, is located physically within a larger dataset. Theoretically, a dataset may be as small as a single feature or feature attribute contained within a larger dataset. A hardcopy map or chart may be considered a dataset.
dataset series	collection of datasets sharing the same product specification
metadata	data about data
metadata element	discrete unit of metadata *NOTE* 1: Equivalent to an attribute in UML terminology. *NOTE* 2: Metadata elements are unique within a metadata entity.
metadata entity	set of metadata elements describing the same aspect of data *NOTE* 1: May contain one or more metadata entities. *NOTE* 2: Equivalent to a class in UML terminology.
metadata section	subset of metadata which consists of a collection of related metadata entities and metadata elements

5. Metadata profile

The ISO 19115 for metadata comprises about 300 elements that exhaustively describe an information resource. Most of these elements are defined as being optional, i.e. they are not needed for compliance with the international standard but are defined for helping users to understand exactly the described data. Individual organisations may develop a profile of the standard according to their needs. A profile consists of the core metadata elements, an additional set of optional elements that are then declared as mandatory part of the profile. Additionally a profile may add elements, i.e. extensions that are not part of the international standard.

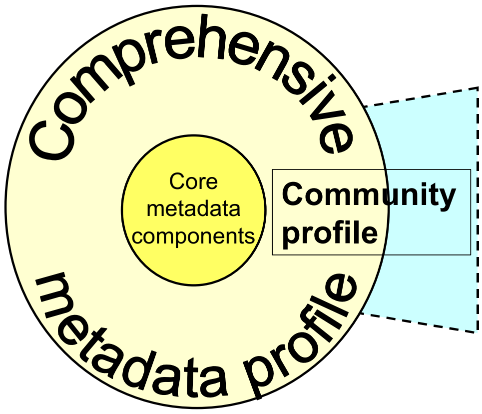


Figure 2: Metadata community profile
No reference to Fig in text

The ISO 19115 describes rules for defining community profiles and extensions. A profile must not change names, the definition or data types of metadata elements. A profile must include all core metadata elements of a digital geographic data set, all mandatory elements in mandatory sections as well as in conditional sections, if the data set meets the condition required by the metadata element. Relationships between the elements have to be identified. Finally, the profile has to be made available to any user of the metadata.

A profile has to follow the rules for defining extensions, too. Metadata extensions are used to impose more stringent obligations on existing metadata elements. In addition, an extension can limit or extend the use of domain values for describing metadata elements.

6. Core and mandatory elements of ISO 19115

The ISO 19115 consists of 22 core elements of which 12 are mandatory to comply with the international standard. The elements are described in Table 1. The mandatory elements focus on the discovery aspect of the metadata (catalogue purposes). Apart from?? information on the metadata itself, they provide information on the title, the category, the reference date, the geographic location, and a short description of the data and the data provider.

The core set expands the mandatory elements with additional information on the type, the scale, the format, the reference system and the data lineage. These elements give rough information on the potential usage of the data.

Table 1: Core metadata elements for geographic datasets (ISO/DIS 19115)

Information about the Metadata

1. Metadata language (C)	(MD_Metadata.language)
2. Metadata character set (C)	(MD_Metadata.characterSet)
3. Metadata file identifier (O)	(MD_Metadata.fileIdentifier)
4. Metadata standard name (O)	(MD_Metadata.metadataStandardName)
5. Metadata standard version (O)	(MD_Metadata.metadataStandardVersion)
6. Metadata point of contact (M)	(MD_Metadata.contact > CI_ResponsibleParty)
7. Metadata date stamp (M)	(MD_Metadata.dateStamp)

Information about the Dataset

8. Dataset title (M)	(MD_Metadata > MD_Identification.citation > CI_Citation.title)
9. **Dataset reference date (M)**	(MD_Metadata > MD_Identification.citation > CI_Citation > CI_Date.date and CI_Date.dateType)
10. Dataset responsible party (O)	(MD_Metadata > MD_Identification.pointOfContact > CI_ResponsibleParty)
11. Geographic location of the dataset (by four co-ordinates or by geographic identifier) (C)	(MD_Metadata > MD_DataIdentification.geographicBox or MD_DataIdentification.geographicIdentifier)
12. Dataset language (M)	(MD_Metadata > MD_DataIdentification.lauguage)
13. Dataset character set (C)	(MD_Metadata > MD_DataIdentification.characterSet)
14. Dataset topic category (M)	(MD_Metadata > MD_DataIdentification.topicCategory)
15. Spatial resolution of the dataset (O)	(MD_Metadata > MD_DataIdentification.spatialResolution > MD_Resolution.equivalentScale or MD_Resolution.distance)
16. Abstract describing the dataset (M)	(MD_Metadata > MD_Identification.abstract)
17. Distribution format (O)	(MD_Metadata > MD_Distribution > MD_Distributor > MD_Format.name and MD_Format.version)
18. Additional extent information for the dataset (vertical and temporal) (O)	(MD_Metadata > MD_DataIdentification.extent > EX_Extent)
19. Spatial representation type (O)	(MD_Metadata > MD_DataIdentification.spatialRepresentationType)
20. Reference system (O)	(MD_Metadata > MD_ReferenceSystem)
21. Lineage statement (O)	(MD_Metadata > DQ_DataQuality > LI_Lineage.statement)
22. On-line resource (O)	(MD_Metadata > MD_Distribution > MD_DigitalTransferOption.onLine > CI_OnlineResource)

- An "M" indicates that the element is mandatory.
- An "O" indicates that the element is optional.
- A "C" indicates that the element is mandatory under certain conditions.

Each of the ISO 19115 elements is further defined using a set of the following 7 attributes:

1. **Name.** A unique label assigned to a metadata entity or to a metadata element.
2. **Short name and domain code.** Short Name for each element.
3. **Definition.** The metadata element description.
4. **Obligation/Condition**. A descriptor indicating whether a metadata entity or metadata element shall always be documented or not. It may have values Mandatory, Conditional,

or Optional. Condition specifies an electronically manageable condition under which at least one metadata entity or a metadata element is mandatory.

5. **Maximum Occurrence.** Specifies the maximum number of instances the metadata entity or the metadata element may have.
6. **Data Type.** Specifies a set of distinct values for representing the metadata elements; for example, integer, real, string,
7. **Domain.** Specifies for each metadata element the values allowed or the use of free text.

7. Metadata information on data validation according to ISO 19115

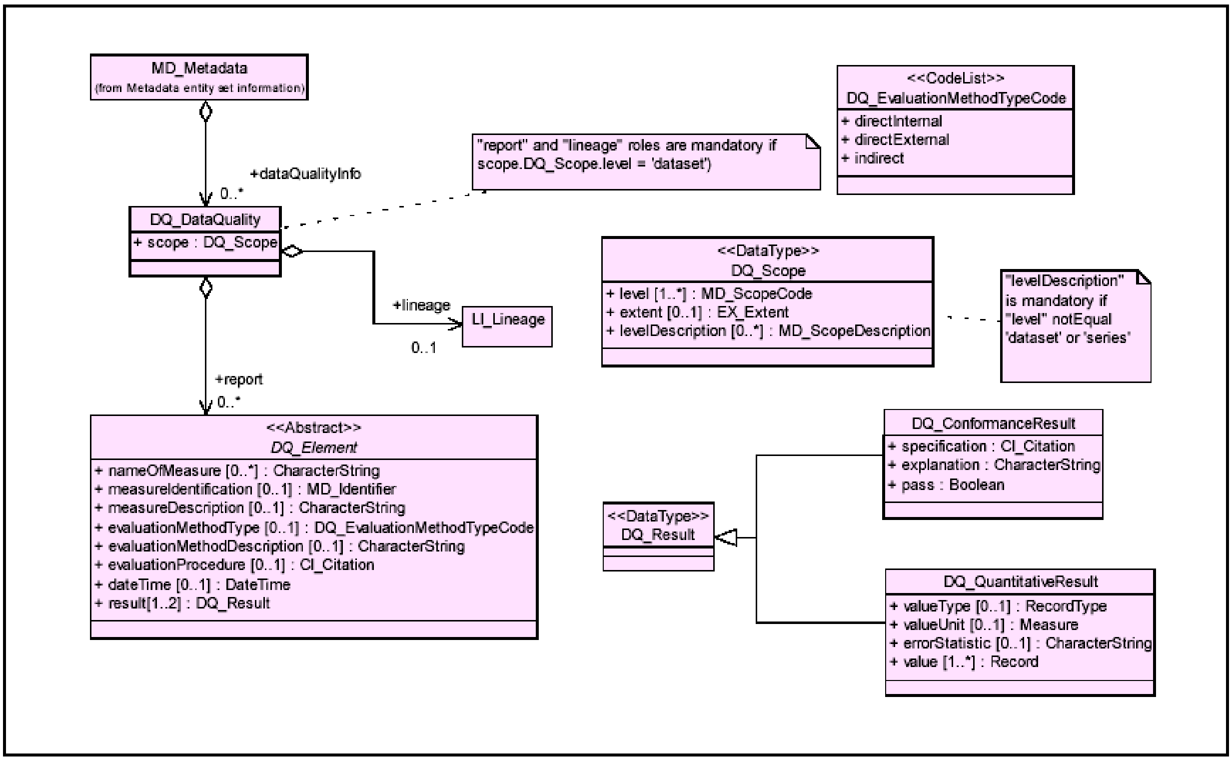


Figure 3: Conceptual model of metadata description on data quality

Bit difficult to read

Table 2: Elements to be integrated into the metadata profile

Name	Description	ShortName	Obligation	Values
MD_Identification		*Ident*		
Purpose	Rationale for creating a dataset and information on intended use; part of data quality overview elements	idPurp	O	
MD_USAGE		*Usage*		
SpecificUsage	Description of the application(s) for which the dataset has been used	SpecUsage	O	
DQ-DataQuality		DataQual	M	
Scope		dqScope	M	
Level	Hierarchical level of the data specified by the scope	scpLvl	M	
Extent	Information about the spatial extent, if test refers to spatial features	scpExt	C / scpLvl = dataset or series or feature or featureType	
EX_GeographicExtent		*GeoExtent*		
Ex_BoundingPolygon		*BoundPoly*	*C / if EX_GeographicBoundingBox and EX_GeographicDescription are empty*	
Polygon	Sets of points defining the bounding polygon	polygon	M	
EX_GeographicBoundingBox		*GeoBndBox*	*C / if EX_BoundingPolygon and EX_GeographicDescription are empty*	
westBoundLongitude	Western most co-ordinate, expressed in longitude in decimal degrees in ETRS89	westBL	M	
eastBoundLongitude	Eastern most co-ordinate, expressed in longitude in decimal degrees in ETRS89	eastBL	M	
southBoundLatitude	Southern most co-ordinate, expressed in longitude in decimal degrees in ETRS89	southBL	M	
northBoundLatitude	Northern most co-ordinate, expressed in longitude in decimal degrees in ETRS89	northBL	M	
EX_GeographicDescription		*GeoDesc*	*C / if EX_BoundingPolygon and EX_GeographicBoundingBox are empty*	
geographicIdentifier		*geoID*		
code	Identifier used to represent a geographic area		M	
DQ_Scope		*DQScope*		
levelDescription		*scpLvlDesc*	*M*	*dataset,*

				series, ….
LI_LINEAGE		*Lineage*		
statement	General explanation of the data producer's knowledge about the lineage of the dataset	statement	C / DQ_Scope.level = "dataset" or "series" and source and processStep not provided	
processStep		*prcStep*	*C / statement and source are not provided*	
description	Description of an event in the creation process for the data specified by the scope, including related parameters or tolerances	stepDesc	M	
source			*C / statement and procStep are not provided*	
description	Detailed description of the level of the source data used in creating the data specified by the scope	srcDesc	M	
REPORT		*dqReport*		
DQ_Element	*The following information applies to one of the data quality elements or sub-elements.*	*DQElement*	*M / all tests specified in the handbook*	
nameOfMeasure	Name of the test applied to the data	measName	M	
measureIdentification	Code identifying a standard procedure as described in the handbook	measID	C / if measDesc, evalMethType, evalMethDesc not provided; ID according to Handbook	
measureDescription	Description of the measure being determined	measDesc	C / if measID not provided	
evaluationMethodType	Type of method used to evaluate quality of the dataset	evalMethType	C / if measID not provided	1=directInternal, 2=directExternal, 3=indirect
evaluationMethodDescription	Description of the evaluation method	evalMethDesc	C / if measID not provided	
dateTime	Date on which data quality measure was applied	measDateTime	M	
result	*Value (or set of values) obtained from applying a data quality measure (quantitative result) or the outcome of evaluating the obtained value against a specified acceptable conformance quality level (conformance result)*	*measResult*	*M*	
DQ_ConformanceResult		*ConResult*	*C / if DQ_QuantitativeResult not provided*	
specification	*Citation of product specification or user*	*ConSpec*	-	

	requirement against which the data is being evaluated			
title	Name by which the cited resource is known	ResTitle	M	
explanation	Explanation of the meaning of conformance for this result	conExpl	M	
pass	Indication of the conformance result	conPass	M	1 =pass, 0 = fail
DQ_QuantitativeResult		*QuanResult*	*C / if DQ_ConformanceResult not provided*	
valueType	Value type for reporting a data quality result	quanValType	M	
valueUnit	value unit for reporting a data quality result	quanValUnit	M	
Value	Quantitative value or values, content determined by the evaluation procedure used	quanVal	M	

Elements in **bold** are mandatory. Elements in *italics* are abstracts.

Explanation

The table (Table 2) describes the elements, that have to be integrated into the metadata profile for providing non quantitative quality information as well as information on applied data validation procedures as described in the part on data validation.

General information on the scope

The first part of the metadata documentation defines the scope to which the data quality information applies. The hierarchical level of the scope can be selected from a code list. If the information given is related to spatial features, then the geographic extent of the spatial features has to be specified. This can be done by means of a bounding polygon, a bounding rectangle or a geographic locator. All co-ordinates should be expressed in the ETRS89 co-ordinate reference system.

Lineage description

Non quantitative quality information is described as lineage of the dataset. For the description of lineage, there are three different alternatives. The first option is to include general information that summarises the knowledge of the data producer on the dataset. The second option is to give a detailed description on the data sources that were used to compile the dataset. The third option consists of an explanation of the processing steps that were applied to the dataset.

Quantitative quality information

Quantitative quality information is included in a report. The metadata profile distinguishes between reports on conformance testing and tests that yield a quantitative result. A quantitative result may be a value for the spatial accuracy of a dataset. A maximum acceptable error of distortion could be used as a threshold to determine whether the derived value is acceptable or not. The first information is related to a quantitative result, the second gives a conformance result.

The first item consists of information on the measurement that was applied to the data. Either there is an identifier that relates to the identifier in the handbook on data validation, or a description of the measurement has to be included. Depending on the type of test, conformance or quantitative result, either information on the conformance, i.e. title, explanation and result, or information on the measured values, i.e. type of value, unit and the value itself, have to be added to the metadata.

8. Metadata information on constraint information according to ISO 19115

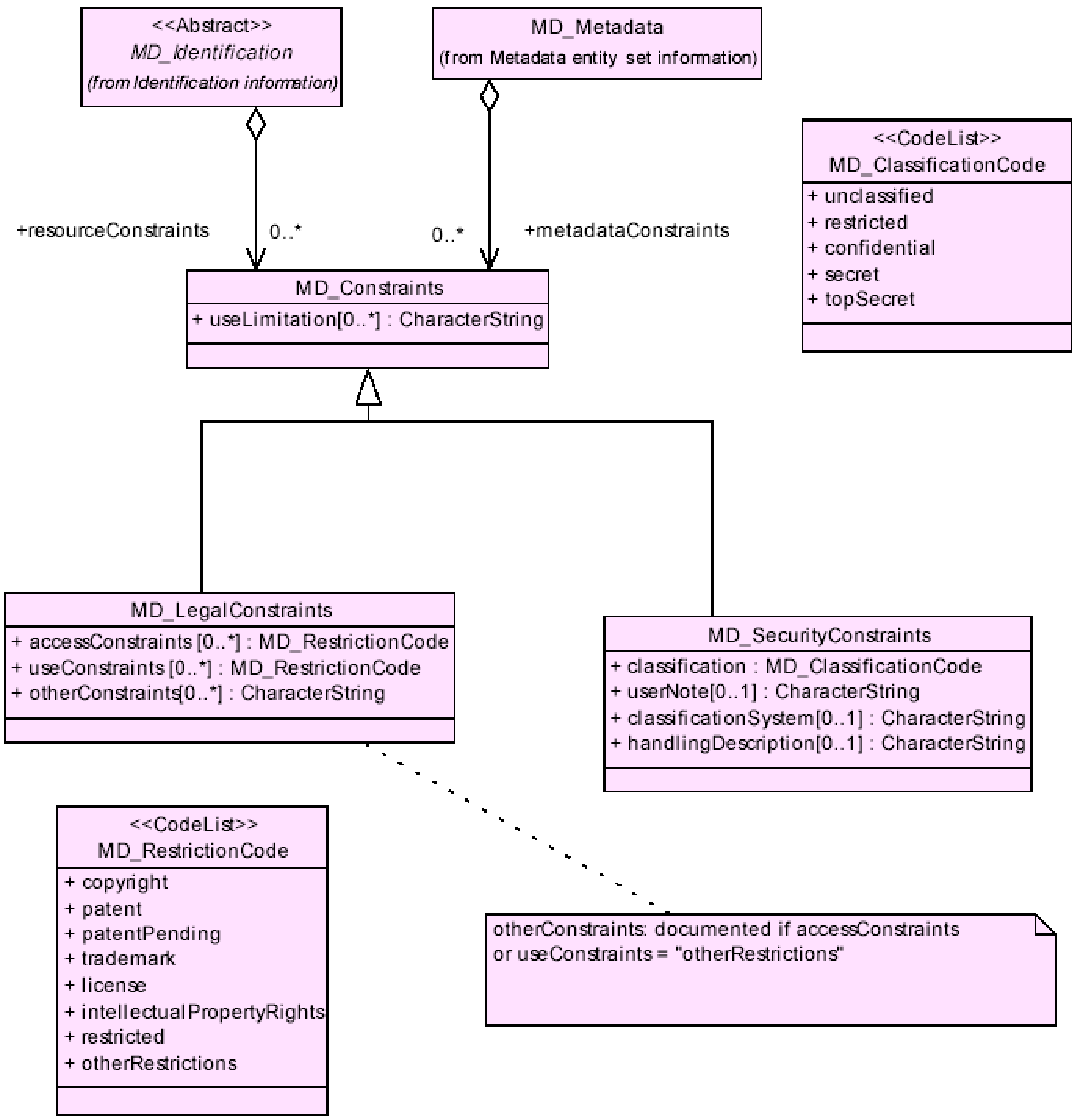


Figure 4: Constraint information

Table 3: Elements, to be integrated into the metadata profile for providing legal and security information.

Name	Description	ShortName	Obligation	Values
MD_Constraints	restrictions on the access and use of a resource or metadata	Consts	M Use obligation from referencing object	
UseLimitation	limitation affecting the fitness for use of the resource. Example, "not to be used for navigation"	useLimit	M	
MD_LegalConstraints	restrictions and legal prerequisites for accessing and using the resource	LegConsts	M	
AccessConstraints	access constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations on obtaining the resource	accessConsts	M	
useConstraints	constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations or warnings on using the resource	useConsts	M	
otherConstraints	other restrictions and legal prerequisites for accessing and using the resource	othConsts	C / accessConstraints or useConstraints equal "otherRestrictions"?	
MD_SecurityConstraints	handling restrictions imposed on the resource for national security or similar security concerns	SecConsts	M	
Classification	name of the handling restrictions on the resource	class	M	
UserNote	explanation of the application of the legal constraints or other restrictions and legal prerequisites for obtaining and using the resource	userNote	M	
HandlingDescription	additional information about the restrictions on handling the resource	handDesc	O	

Elements in bold are mandatory. Elements in italics are abstracts.

Explanation

The table (Table 3) describes the elements, that have to be integrated into the metadata profile for providing legal and security information.

Appendix VIII: Detailed Description of the GML Specification

Co-ordinates Element

A co-ordinate list is a simple list of co-ordinate tuples. The separators used to parse the co-ordinate list are encoded as attributes of the <co-ordinates> tag. In the example below, the co-ordinates in a tuple are separated by commas, and the successive tuples in the <co-ordinates> are separated by whitespace. A co-ordinate list is not a geometry in the Simple Features sense, merely the co-ordinate content. All tuples in the string must have the same dimension. A co-ordinate list is given by the following grammar.

```
<decimal>::='.'
<D>:=[0-9]
<cs>::=","
<ts>::=whitespace (see XML 1.0 [XML]
<co-ordinate>::='-'<D>+(<decimal><D>+)?
<ctuple>::=<ctuple>|<coordinate><cs><ctuple>
<coordinatelist>::=<coordinatelist>|<ctuple><ts><coordinatelist>
```

```
Note that the value of decimal, cs, and ts are determined by the GML
encoding of <co-ordinates>. The grammar is illustrated for default values
of decimal, cs and ts.
```

To find the co-ordinates of any Geometry class instance we introduce the co-ordinate property. We think of this as a function on the Geometry class instance that returns the co-ordinates as a co-ordinate list. The co-ordinate property has the associated DTD fragment:

```
<!ELEMENT co-ordinates (#PCDATA) >
<!ATTLIST co-ordinates
decimal CDATA #IMPLIED
cs CDATA #IMPLIED
ts CDATA #IMPLIED>
```

Note that the default for decimal is '.', for cs is ',' and for ts is whitespace.

<u>Example</u>

```
<co-ordinates decimal="." cs="," ts="whitespace">
1.03,2.167 4.167,2.34 4.87,3.0 1.06,2.3
</co-ordinates>
```

Point Element

The Point Element is used to encode instances of the Point geometry class. Each Point Element encloses a single co-ordinates element, the latter containing one and only one co-ordinate tuple. A Point geometry must specify a SRS in which its co-ordinates are measured. This is referenced by name. Thus the Point element has an srsName attribute. However this is defined to be optional. This is to allow the Point element to be contained in other elements which might have already specified a SRS. Similar considerations apply to the other geometry elements. The Point element also has an optional ID attribute. The DTD fragment for the Point element is as follows:

```
<!ELEMENT Point (co-ordinates) >
<!ATTLIST Point
ID CDATA #IMPLIED
srsName CDATA #IMPLIED>
```

LineString Element

A Line String is a piece-wise linear path. The path is defined by a list of co-ordinates that are then assumed to be connected by straight line segments. A closed path is indicated by having coincident first and last co-ordinates. At least two co-ordinates are required. The DTD fragment is as follows:

```
<!ELEMENT LineString (co-ordinates) >
<!ATTLIST LineString
ID CDATA #IMPLIED
srsName CDATA #IMPLIED >
```

LinearRing Element

A Linear Ring is a closed, simple piece-wise linear path. The path is defined by a list of co-ordinates that are then assumed to be connected by straight line segments. The last co-ordinate must be coincident with the first co-ordinate. At least four co-ordinates are required (the three to define a ring and the fourth duplicated one). Since a LinearRing is used in the construction of Polygons, which define their own SRS, it has no need to define a SRS. The DTD fragment is as follows:

```
<!ELEMENT LinearRing (co-ordinates) >
<!ATTLIST LinearRing
ID CDATA #IMPLIED >
```

Polygon Element

A Polygon is a connected surface. Any pair of points in the polygon can be connected to one another by a path. The boundary of the Polygon is a set of Linear Rings. We distinguish the outer (exterior) boundary and the inner (interior) boundaries. The Linear Rings of the interior boundary cannot cross one another and cannot be contained within one another. There must be at most one exterior boundary and zero or more interior boundary elements. The ordering of Linear Rings, whether they form clockwise or anti-clockwise paths, is not important. A Polygon is encoded via the DTD fragment:

```
<!ELEMENT Polygon (outerBoundaryIs, innerBoundaryIs*) >
<!ATTLIST Polygon
ID CDATA #IMPLIED
srsName CDATA #IMPLIED >
   <!ELEMENT outerBoundaryIs (LinearRing) >
   <!ELEMENT innerBoundaryIs (LinearRing) >
```

Appendix IX: Glossary of Terms

Term	Definition
Accuracy	Closeness of agreement between a test result and the accepted reference value (RDM)
Altitude	Elevation above or below a reference surface (RDM)
Architecture	The models, standards, technologies, specifications and procedures involved in using digital information
AST – INSPIRE	Standards and Architecture – INSPIRE Working group
Attribute	A defined characteristic of an entity type (e.g. composition) (RDM)
Attribute value	A specific quality or quantity assigned to an attribute
Background (Layer)	Display of an orthoimage in the background of other spatial data providing information on the context (RDM)
Bathing Directive	Directive 76/160/EEC
Birds Directive	Directive 79/409/EEC
Catalogue (1)	A mechanism for making third parties aware of available material. A clearinghouse directory. (ISF)
Catalogue (2)	Distributed service to locate geospatial data based on their characteristics expressed in metadata (ISF)
Catalogue services	Also called Clearinghouse. Cf. *Catalogue (2)* (AST - DERM)
CEN	REFCOND: European Committee for Standardization
Class	A set of objects that share the same attributes or characteristics
Clearinghouse (1)	A decentralised system of servers on the Internet which contain metadata (FGDC)
Clearinghouse (2)	A central agency for the collection, classification and distribution especially of information (RDM)
Completeness-attribute	The degree to which all relevant attributes of a features have been encoded (RDM)
Completeness - data	A measurable error of omission and commission observed between the database and the specification (RDM)
Completeness - model	The agreement between the database specification and the abstract universe (RDM)
Completeness - value	The degree to which values are present for all attributes
Concatenating	Combining two or more keys
Conformal projection	A projection on which all angles at each point are preserved. (RDM)
Conformance	Consistency with pre-stated capabilities and specifications
Conformance testing	Testing of a candidate product to determine the extent to which it satisfies the conformance requirements (RDM)
Consistency	Refers to the absence of apparent contradictions in a database. (RDM)

Co-ordinate(s)	Pairs of numbers (abscissa and ordinate) expressing horizontal distances along orthogonal axes (RDM)
Dangling node	Node connected to one line element only. Typically sources and outlets of river segments are dangling nodes.
Data	A formalised collection of facts, concepts or instructions for communication or processing by humans or by computer
Data dictionary	A catalogue of all data held in a database, or a list of items giving data names and structures
Data element	A logically primitive item of data
Data layer	Cf. *Layer*
Data model (1)	The result of the conceptual design process. A generalized, user-defined view of the data related to applications
Data model (2)	A formal method of describing the behaviour of the real-world entities. A fully developed data model specifies entity classes, relationships between entities, integrity rules and operations on the entities
Database	3.1 GIS: A collection of related data organised for efficient retrieval of information (RDM)
Dataset	3.1 GIS: A collection of data on a common theme or having similar attributes (RDM)
Dataset with geographic datatype	3.1 GIS: georeferenced digital dataset
Datum	A model of the earth's shape used for Geodetic calculations (RDM)
Delivery	The process of transferring possession from one individual or organisation to another
Digital Elevation Model (DEM)	A digital representation of a topographic surface (RDM)
Directive	Legal instrument binding as to the result to be achieved. Usually requires additional legislation at MS level
Dissemination	The publication of data to multiple users
Distribution	The process of moving products from supplier to consumer
Domain	Identifies valid values for a data element in the metadata standard definition (RDM)
Dublin Core	Metadata standard promoted by the Dublin Core Metadata Initiative (www.dublincore.org)
Elevation	Vertical height above a theoretical earth's surface base
Elevation	Cf. *Altitude*
Ellipsoid	The three-dimensional shape obtained by rotating an ellipse about its minor axis. (RDM)
Entity	A real world object that cannot be further subdivided into similar objects. (RDM)

Exclave	Polygon related to another polygon without having an explicit geometric relationship
Feature	A point, line or polygon in a spatial database that represents a real-world entity (RDM)
FGDC	Federal Geographic Data Committee (www.fgdc.gov)
Field	In database applications describes a space in which data of the same type is entered
Fish water Directive	Directive 78/659/EEC
Geographic Co-ordinates	A measurement of a location on the earth's surface expressed in degrees of latitude and longitude
Geographic data	The locations and descriptions of geographic features; the composite of spatial and descriptive data (RDM)
Geographic datatype	Category of geometric representation of geographic features (e.g. points, lines, polygons)
Geographic feature	Abstraction of a real world phenomenon associated with a location relative to the Earth (AST)
Geographic information	Information that is referenced to the earth's surface, whether by co-ordinates or by identifiers such as addresses
Geoid	The equipotential surface of the Earth's gravity field, which corresponds most closely with mean sea level and extends continuously through the continents.
Geometry	The scientific study of the properties of and relations between measures of points, lines and surfaces. In a GIS geometry is used to represent the spatial component of geographic features
Georeferencing	The process of determining the relation between the position of data in the co-ordinate system and its map location (RDM)
GIS	A system for capturing, storing, checking, manipulating, analysing and displaying data which are spatially referenced to the Earth (UK Department of the Environment, 1987)
Grid	An array of equally sized square cells arranged in rows and columns referenced by geographic x,y location (RDM)
Habitats Directive	Directive 92/43/EEC
Harmonise/harmonisation	Be in line with, in accordance with, in conformity (AST)
Horizontal	Tangent to the geiod or parallel to a plane that is tangent to the geiod (RDM).
Horizontal/vertical	Horizontal means different user sectors; vertical means the global to local axis (ISF)
INSPIRE	Infrastructure for Spatial Information in Europe (http://egeols222.egeo.sai.jrc.it/inspire/)
ISF - INSPIRE	Implementing Structures and Funding - INSPIRE Working Group
Integration	The bringing together of previously segregated or separated units

Interoperability	The ability of two or more systems to operate in conjunction with each other (cf. RDM & IEEE 90). Semantic interoperability cf. Semantics
Lambert Azimuthal Equal Area	An azimuthal projection that sacrifices shape and distance but preserves area (RDM)
Lambert Conic Conformal	A projection of the earth's surface on a tangent cone normally based on two standard parallels (RDM)
Latitude	The angular distance along a meridian north or south of the equator expressed in degrees, minutes and seconds
Layer	A collection of similar features in a particular area referenced together for display on a map (RDM)
Level	The area over which unified specifications will apply, i.e. pan-European, national or local (RDM)
Line	A set of ordered co-ordinates that represent linear features with no area (RDM)
Location	Identifiable part (place) of the real world (RDM)
Long term	Usually held to be more than two years
Longitude	The angular distance east or west from a standard meridian such as Greenwich to the meridian of any place
Map	A graphical representation of a section of the earth's surface displayed on a planar surface
Map projection	Cf. Projection
Medium term	Usually held to be 6 months to 2 years
Member State (MS)	One of the (currently) fifteen members of the European Union
Metadata	Description of the characteristics of a set of data
Metadata element	One of the items that collectively form a metadata structure (OeE)
Metadata record	A full set of structured relevant metadata describing one information resource
Model	An abstraction of reality used to represent objects, processes or events. (RDM)
Nitrates Directive	Directive 91/676/EEC
Node	A zero-dimensional object that is the topological junction of two or more links or an end point of a link (RDM)
Object	The representation of a real-world entity with properties and relationships with other objects (RDM)
OpenGIS	Transparent access to heterogeneous geodata and geoprocessing resources in a networked environment (RDM)
Parse	Handling over of parameters from one transformation to another
Point	A zero-dimensional abstraction of an object represented by a single x,y co-ordinate (RDM)
Policy	A set of obligations, prohibition or permission rules that either constrain or enable action (AST)

Polygon	An irregular two-dimensional figure enclosing a pre -defined area or an area of common characteristics
Positional accuracy	The accuracy of the spatial component of a database. (RDM)
Precision	A measure of the statistical uncertainty equal to the half width of the C% confidence interval. For any one monitoring exercise, the estimation error is the discrepancy between the answer obtained from the samples and the true value. The precision is then the level of estimation error that is achieved or bettered on a specified (high) proportion C% of occasions.
Projection (1)	The technique used to convert the three-dimensional reality of the earth's surface into a two -dimensional image
Projection (2)	A mathematical model that transforms the reality of the earth's surface to a two-dimensional representation
Protocol	A conventional and accepted method of fulfilling a task
Prototype	A non-operational system for testing purposes
Quality	An essential or distinguishing characteristic necessary for cartographic data to be fit for use (RDM)
Quantitative status	Expression of the degree to which a body of groundwater is affected by direct and indirect abstraction *cf.* Art 2(28) 'good quantitative status'
RDM -INSPIRE	Reference data and metadata – Inspire working group
Reference data	Data necessary to identify the position of physical features in relation to other information in a geospatial context
Reference system	A method for identifying and relating different positions on the earth's surface
Scale	The relation between the dimensions of features on a map and the objects they represent on the earth (RDM)
Scale – large	> 1:25,000 with resolution range < 2.5m (RDM)
Scale – medium	1:25,000 to 1:250.000 with resolution range 10m
Scale – small	< 1:250.000 with resolution range > 100m (RDM)
Schema	Visual representation and simplification of complex relationships and dependencies.
Semantics	The meaning of words
Short term	Usually held to be up to six months
Spatial accuracy	Cf. *Positional accuracy*
Spatial data / information	Identifies the geographic location and characteristics of features and boundaries on the earth (RDM)
Spatial data set	Cf. data set with *geographic datatype*
Spatial Data Infrastructure	The relevant base of technologies, policies and institutional arrangements that facilitate data availability and access
Spatial resolution	The ground dimensions of the pixels making up the digital image (RDM)
Specification/s	A detailed description of construction and performance

Standard(s)	Includes the ISO 19100 series of standards, OGC, CEN and others
Symbology	Visual representation, simplification and classification of objects
Tabular	Data arranged in tables or lists
Topology	Properties of geometric forms remain invariant when the forms are deformed or transformed (RDM)
Transformation	Set of sequentially applied computer instructions yielding a change of one or more parameters.
Transverse Mercator	A projection resulting from projecting the sphere onto a cylinder tangent to a central meridian (RDM)
Type specific reference conditions.	2.3 REFCOND: Reference conditions (see separate definition) representative for a specific water body type.
Tuple	Unique set of parameters in a relational database.
Typology	The study and interpretation of types
Urban Waste Water Treatment Directive	Directive 91/271/EEC
Vector	Ordered list of co-ordinates used to represent linear features
Vertical	At right angles to the horizontal; includes altitude and depth (RDM)
Web mapping	The provision of map based information services on the Internet

Appendix X: References

Chapter 3.4: Feature Coding

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[1] *Country Codes follow ISO 3166-1-Alpha-2: Country names and code elements (http://www.din.de/gremien/nas/nabd/iso3166ma/codlstp1/en_listp1.html)*

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