Sep 1 - Sep 4, 2008, Montpellier, FRANCE XIIIth IWRA World Water Congress.

INFO: e-mail wwc2008@msem.univ-montp2.fr; Web: http://wwc2008.msem.univ-montp2.fr

TITLE: EWATER: THE EUROPEAN MULTILINGUAL GROUND WATER INFORMATION SYSTEM.

Full name of author and co-authors
E. Balloffet[1], A. Tchistiakov[2], J. Jellema[2], M.Hansen[3], Steven Fruijtier[4], Martijn van Exel[4], J. Theelen[5], An Heirman[5], D. J.Rodriguez[6], D. Capova[7], J. Belickas[8], Audrius Pozingis[8], Anna Murnikova[9], Jurga Arustienė[9], Gerhard Schubert[10], A. Rotar-Szalakai[11], P. Nagy[11], Jasna Sinigoj[12], Addolorata Palumbo[13], Peter Malik[14], Magnus Asman[15].

1 Geological Survey of France, Orleans, France
2 The Geological Survey of the Netherlands (TNO), Utrecht, Netherlands
3 GEUS, Copenhagen, Denmark
4 Geodan, Amsterdam, Netherlands
5 G.I.M. Geographic Information Management NV, Belgium
6 The Geological Survey of Spain, Madrid, Spain
7 Geofond, Prague, Czech Republic
8 Informacinės technologijos, Vilnius, Lithuania
9 Geological Survey of Lithuania, (LGT)
10 Geological Survey of Austria (GBA)
11Geological Institute of Hungary, Budapest, Hungary
12 Geological Survey of Slovenia, Ljubljana, Slovenia
13 Geological, Seismic and Soil Survey of Emilia-Romagna Region, Italy
14 Geological Survey of Slovakia
15 Geological Survey of Sweden

Identification of the Congress Sub-theme most closely related to the paper :
DEVELOPMENT OF WATER RESOURCES AND INFRASTRUCTURE / Data, monitoring and information technology

INTRODUCTION

Results of recent delineations of the water bodies in Europe, complying with the requirements of the Water Framework Directive, showed that more than 60% of the European basins are international, comprising territories that belong to more than one European country. However the hydrogeological data is currently stored in national databases and available exclusively for a national user in a local language. Therefore the hydrogeological data across the national borders forms separated, uncorrelated and not interoperable data sets. As the result much of the hydrogeological spatial information is difficult to exploit in both international and national water management context.

The main objective of the new EC co-funded project "Multilingual cross-border access to ground water databases" (eWater: www.eWater.eu) is to increase the cross-border availability, accessibility and re-usability of spatial data on quality, location and use of subsurface waters. It has been achieved by developing a web GIS portal for hydrological and geological data in relation to water management issues of the participating countries. The cross-border portal is meant for EC itself, national and river basin water authorities, water suppliers, added-value data service companies, insurance companies, planning and controlling organizations, the general public.

The main distinguishable features of the eWater system are:

1. a central web portal, focal point for presentation of the hydrogeological data from participating EU countries
2. a common data delivery format
3. common user interfaces into different national databases
4. on-fly-translation services for user interfaces and data itself

A special eWater-Mobile application enables water specialists, operating in the field, to check recent groundwater measurement by means of a mobile handheld computer (UMPC in combination with GPS).

Consortium

The project lasts from September 2006 to August 2008. It involved twelve Geological Surveys and three commercial data service companies:

1. The Geological Survey of the Netherlands (TNO)
2. Geological Survey of France (BRGM)
3. Geological Survey of Denmark and Greenland (GEUS)
4. Geological Institute of Hungary (MAFI)
5. Czech Geological Survey (Geofond)
6. Geological Survey of Slovak Republic (GSSR)
7. Geological, Seismic and Soil Survey of Emilia-Romagna Region (SGSS), part of the Italian Geological Survey
8. Geological Survey of Austria (GBA)
9. Lithuanian Geological Survey (LGT)
10. Geological Survey of Slovenia (GeoZS)
11. The Geological Survey of Spain (IGME)

12. Geological Survey of Sweden (SGU)
13. Informacines technologijos (Information Technologies (IT), Lithuania)
14. GIM Geographic Information Management NV (Belgium)
15. Geodan Mobile Solutions (the Netherlands)

INVENTORY AND DEFINITION PHASE

During this phase of the project we analyzed *organizational and institutional aspects of ground water data management at the national levels* that are considerably different in the participating countries. We identified the *requirements for data delivery at EU and national users' levels*. We collected the information regarding *availability and interoperability of hydrogeological maps*. Further we analysed the existing technical solutions (*Best Practices*) regarding description, collection, storing, retrieving, evaluating and distributing hydrogeological data.

The results of these investigations have insured that the eWater system would be built based on the most advanced technologies and would satisfy the needs of the current national users as well as new international ones, including the European Commission.

Requirements for data delivery at EU and national users' levels

The user requirements were prepared based on interviewing more than 100 experts, representing different user groups, i.e. geological surveys, national government and provincial authorities, private companies, water suppliers, universities, and international water management organisations.

Datasets

Analysis of the questionnaires received from the different user groups allowed us to conclude that for ground water monitoring the most valuable are the data sets concerning ground water levels, hydrochemistry (Figure 1), pumping tests and withdrawals. This "prime" data is obtained from hydrogeological wells.

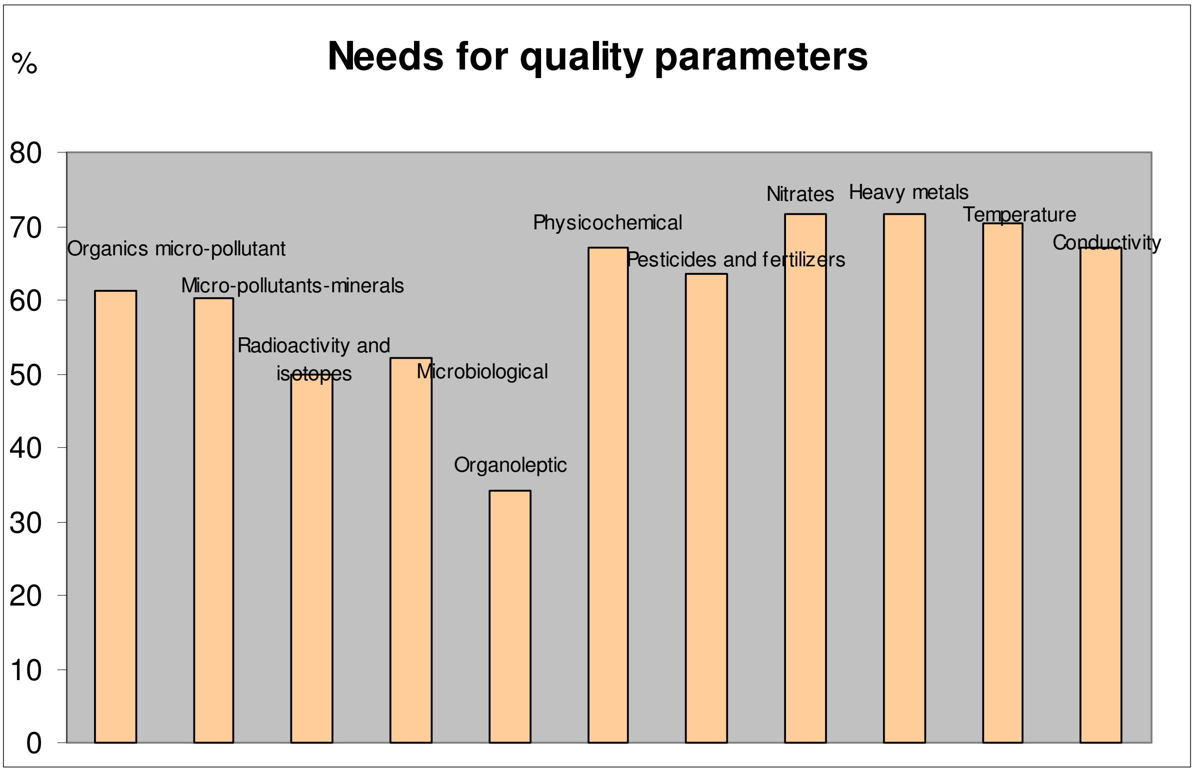

Figure 1: needs for quality parameters

Among ground water thematic maps, the most popular are the maps concerning groundwater resources, aquifer vulnerability, water pollution, hydrochemical elements distribution (nitrates, chlorides, pesticide, etc.), geology, protection areas, land and water use. The majority of experts, involved in water management at local level, expressed their interest in large scale maps only, however the groups involved in international water management expressed their interest in smaller scale maps covering several regions and even countries (e.g. International Hydrogeological map of Europe, scale 1:1,500,000; http://www.bgr.de/app/ihme1500/).

User functional requirements
Many potential users emphasised that eWater GIS portal should allow visualization of data and maps, including the maps available within their organisations. Quite a few of them expressed interest in the possibilities of downloading of data, maps, metadata, reports and summarized information concerning groundwater investigations. As supplementary options several users suggested the portal should include links to relevant international research projects, as well as scientific forum for exchanging expertise regarding data management and interoperability issues.

Regarding eWater mobile services specialists, operating in the field, expressed their prime interest in the possibilities of visualization of basic well data, including time series and trends graphs, downloading the well data, accessing thematic maps, well data input.

Organisation of ground water data management in the participating countries

All the countries, participating in eWater project, have quite strict regulations defining collection of hydrogeological data, their verification and input into a database as well as further dissemination to national users. The institutions producing hydrogeological data (e.g. from field survey) are of similar type in the different countries. However the data collection, verification, input and hosting in databases can be done by various kinds of state institutions, mainly by municipalities, water and environmental authorities, research institutes (
Figure 2; for Italy the data is only shown for Emilia-Romagna Region). Due to the wide thematic range of hydrogeological data (point data, time series, maps) various data sets are managed in different ways and they are frequently stored in different databases. The specific data types can occasionally be hosted even by different institutions.

Most well data is public in the participating countries (Figure 3). However water production data is usually not of free access. Well data is available mainly in a digital format; otherwise it can be digitized upon a user request. Web-based access to the data is quite common but usually does not include all range of information available.

The national price policies are quite different. Although well data itself is mainly free of charge, data services (i.e. maintenance of the database applications) as well as data pre-processing must frequently be paid. In some cases a user is charged based on the amount of data ordered. In other cases a user has to pay a yearly flat rate regardless the amount of data downloaded.

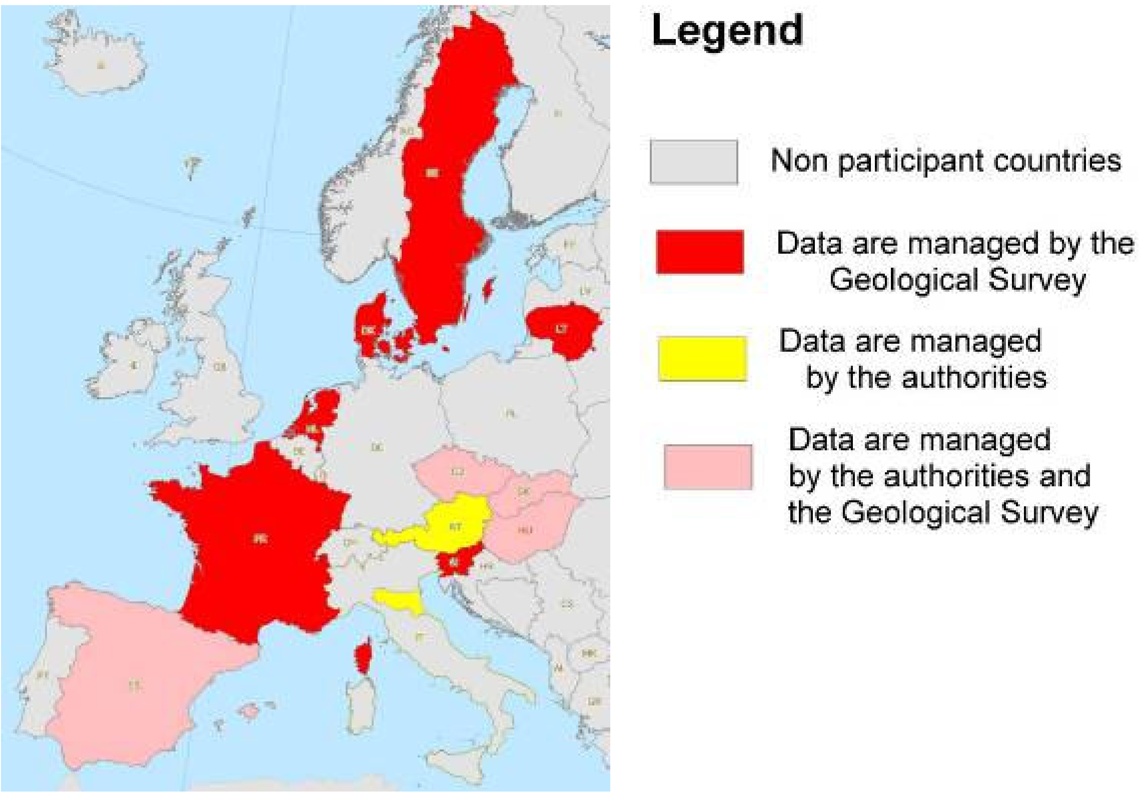

Figure 2: Organizations responsible for well data management

Availability and interoperability of hydrogeological maps

Hydrogeological maps are synoptic representations that portray information on groundwater and the hosting rock bodies on a topographic base. They define the spatial and temporal location and utilization of water resources, constituting the base for policy development in the field of water resources management and geological hazards assessment and, in general, the management of the territory. These maps contain knowledge infrastructure that is also the base for technical and scientific developments in many areas of the environmental sciences.

Hydrogeological maps have a long historical evolution from geology-oriented paper maps to digital maps including modern visualization features, and have been derived from projects and plans having different purpose and funding frameworks, as well as different scale and information basis. The national Geological Surveys have been responsible for the elaboration of the hydrogeological cartography for decades, and have now an important role in the management of the information on the geographical definition of the ground water bodies, their hydrodynamic properties and their flow models in compliance with the requirements of the Water Framework Directive (WFD). Most of them are also presently involved in huge digitalization plans of the hydrogeological cartography that they have produced in order to make available the digital cartographic products to society and technical and scientific users. The Digitalization plans as a rule include updating and re-edition works.

Figure 3: Dissemination of ground water head data.

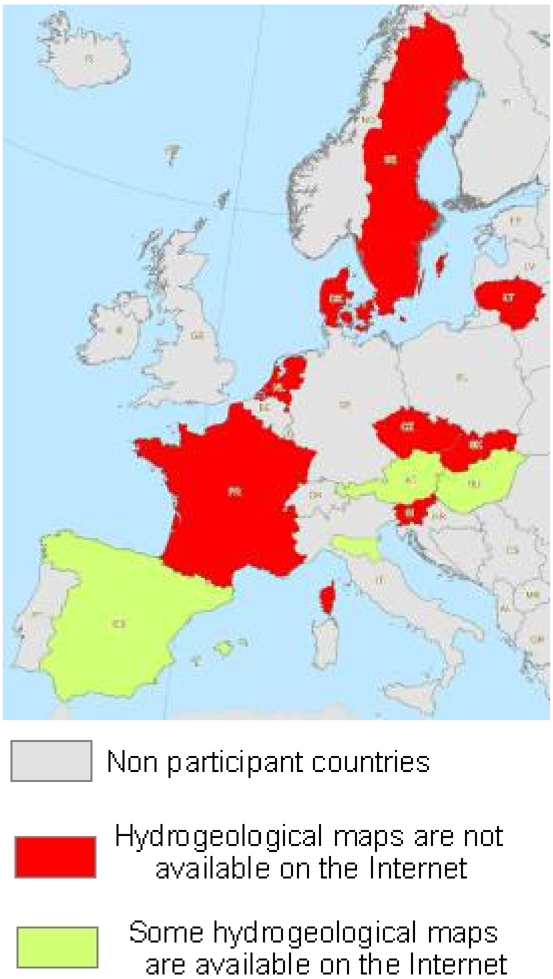

Figure 4: Dissemination of hydrogeological maps.

The results of a survey, conducted in the frame of eWater, have provided the first glimpse of the hydrogeological maps available in the twelve project-partner's countries, about half of the countries of the European Union. This information has been structured in a Database accessible through internet (http://www.igme.es/internet/ewater/), from which any user may easily find important information regarding maps and the main organisations responsible for national hydrogeological mapping.

The maps information includes format (paper, digital: raster or vector), scale, coverage, legend (hydrogeological objects represented), projection system, metadata, and availability. The database contains information on some 250 hydrogeological maps available at the Geological Surveys of Austria, Denmark, Emilia Romana (Italy), France, Hungary, the Netherlands, Czech Republic, Lithuania, Slovakia, Slovenia, Spain, and Sweden.
Many of these countries provide web portals with national map catalogues (Figure 4), enabling a user to order different types of Hydrogeological maps, mainly in paper format. Most countries have developed Web GIS applications for internal use of the digital maps. However, there are still few countries providing the public with access to national hydrogeological digital maps. The Netherlands publishes digital layers composing the hydrogeological model of the country instead of a hydrogeological map in the Internet. Since the data layers are regularly updated, different types of thematic ground water maps can be produced, depending on a particular customer needs.

Building the catalogue of the hydrogeological maps has proved to be a necessary step towards interoperability of digital maps. The catalogue provides the answers to "What maps are available" and "What are their main characteristics"? This information then allow us to pose the next question - "How do we enhance their interoperability in the right framework"? Before the catalogue was created we could only speculate about the extent of hydrogeological mapping in Europe and what recommendations could be proposed from eWater on interoperability.

Best practices in the national hydrological data management and distribution

Besides investigation of organization aspects of data management, extensive survey of technical solutions applied by the partners was done by means of questionnaire distributed within eWater consortium.
Analysis of the partner's databases showed that they contain quite significant amount of hydrogeological borehole data and digital hydrogeological maps. The majority of the data is stored in multi-user, relational Oracle databases.
Most of the eWater partners apply recent ISO 19115 metadata standard for description of their digital maps. Numerous applications are in use to edit and access metadata, ranging from the open source application GeoNetwork to specifically developed applications such as GeoSticker, Micka, etc.
Evaluation of the technical solutions against INSPIRE and WISE requirements led us to the following conclusions regarding "best practices" that were considered during development of eWater system.

1. Interoperability: use and implementation of OGC standards is to be encouraged in order to make the geographic information accessible beyond eWater system, e.g. for Water Information System for Europe (WISE viewer).
2. Storing of thematic metadata is to be done in the INSPIRE metadata profile, which is based on ISO 19115 and ISO 19139; the thematic metadata is to be accessible via the internet.

3. Uniformity: delivery of the geo-referenced hydrogeological point measurement data from the national databases is to be done in a common format, in order to simplify both the data exchange within the application and the data dissemination via the central eWater portal.
4. Multilinguality: the eWater portal has to have a multilingual user interface and on-the-fly translation functions for translating coded groundwater measurement data from the national databases.
5. Accessibility: the user application shall be publicly available via a standard webapplication over the Internet.
6. Security: it has to be possible to restrict geographic information to internal use for the eWater partners.
7. Distributed data structure: each geological survey remain responsible for the publication and maintenance of its own data and metadata.
8. Distributed application structure: since each country has specific well data dissemination rules, the software services (or applications), responsible for data delivery, are to be implemented at the data hosting organizations (at national levels). The central eWater system has to use the data delivery services, located in different countries. The data delivery services are to be further maintained by the hosting organization in their normal work flow, in order to insure the system integrity in future.

Since the partners have different levels of “compliance” with the “best practices”, for each partner an individual implementation plan was developed.

Data delivery format for hydrogeological measurements

In the first four months of the eWater project, information concerning data models was collected from all database-owning partners. Geological Surveys possess complex databases with hundreds of fields. The first action was defining, which data elements are the most essential to the market.

From the completed questionnaires a first proposal was elaborated. During further discussions these lists were amended and extended, based on remarks and requests from the partners. This has resulted in an acceptable XML common denominator of data elements that was used for the delivery of groundwater measurement data from national databases to eWater system.

IMPLEMENTATION

Interoperability of digital maps – unified legend map

During the first phase of eWater project, a survey has been made on current hydrogeological maps and models available in the project partners countries. The survey has yielded the database that contains an overview of the maps and models available, specifying their most important characteristics. This database allowed to select for every country the hydrogeological maps to be published in the eWater system (WMS).

On the basis of this information, an attempt has been made to compare the contents of the maps, namely the geological and hydrogeological classifications used by the partner’s countries and to define a high-level harmonised legend. Differences found among hydrogeological and especially among litho- and chrono-stratigraphical classifications were huge. Notwithstanding this, the definition of a common legend (Figure 5) has been attempted in order to explore and identify possible future steps for the harmonization of these maps and models in the eWater project or in future hydrogeological cartographic initiatives in the Member States.

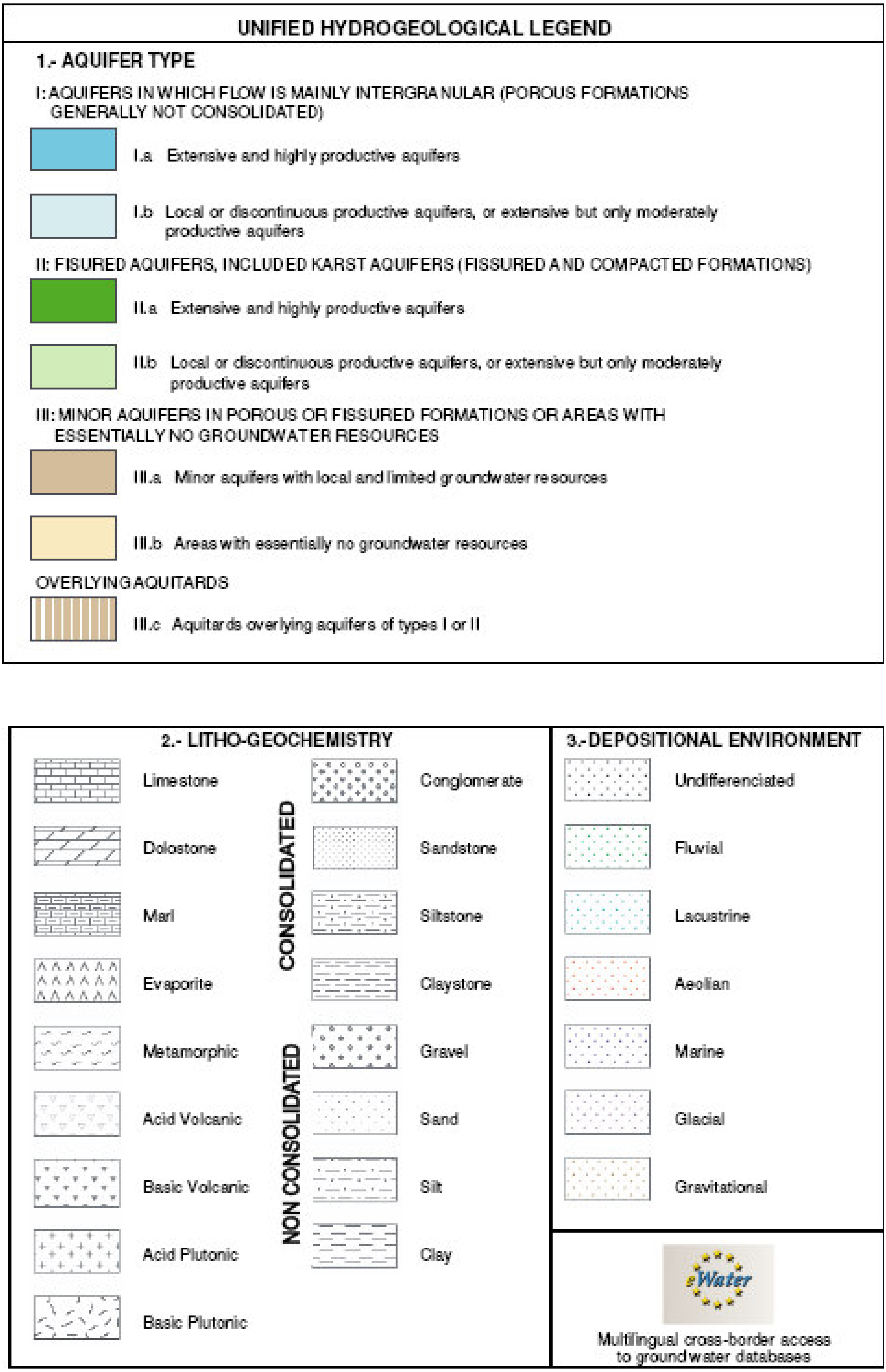

Figure 5 : unified harmonised hydrogeological legend

For every country, it was required a layer depicting the hydrogeological formations in vector format and with the following attributes: Aquifer type, Lithology, Permeability, Chronostratigraphy. In some cases the layer was not available and several geological surveys could not take part to this work.

Implementation of the portal and the website

Collection of metadata through eWater Central Portal and MapViewer

The eWater system has service distributed structure and includes several logical elements (figure 6). Among them is the central web portal that is the focal point for the hydrogeological data dissemination. The portal includes two main components: the metadata catalogue and the GIS viewer, allowing data finding and their visualisation. Both components were built by means of open source software. For metadata catalogue we used Geonetwork, for the web GIS viewer - MapBuilder.

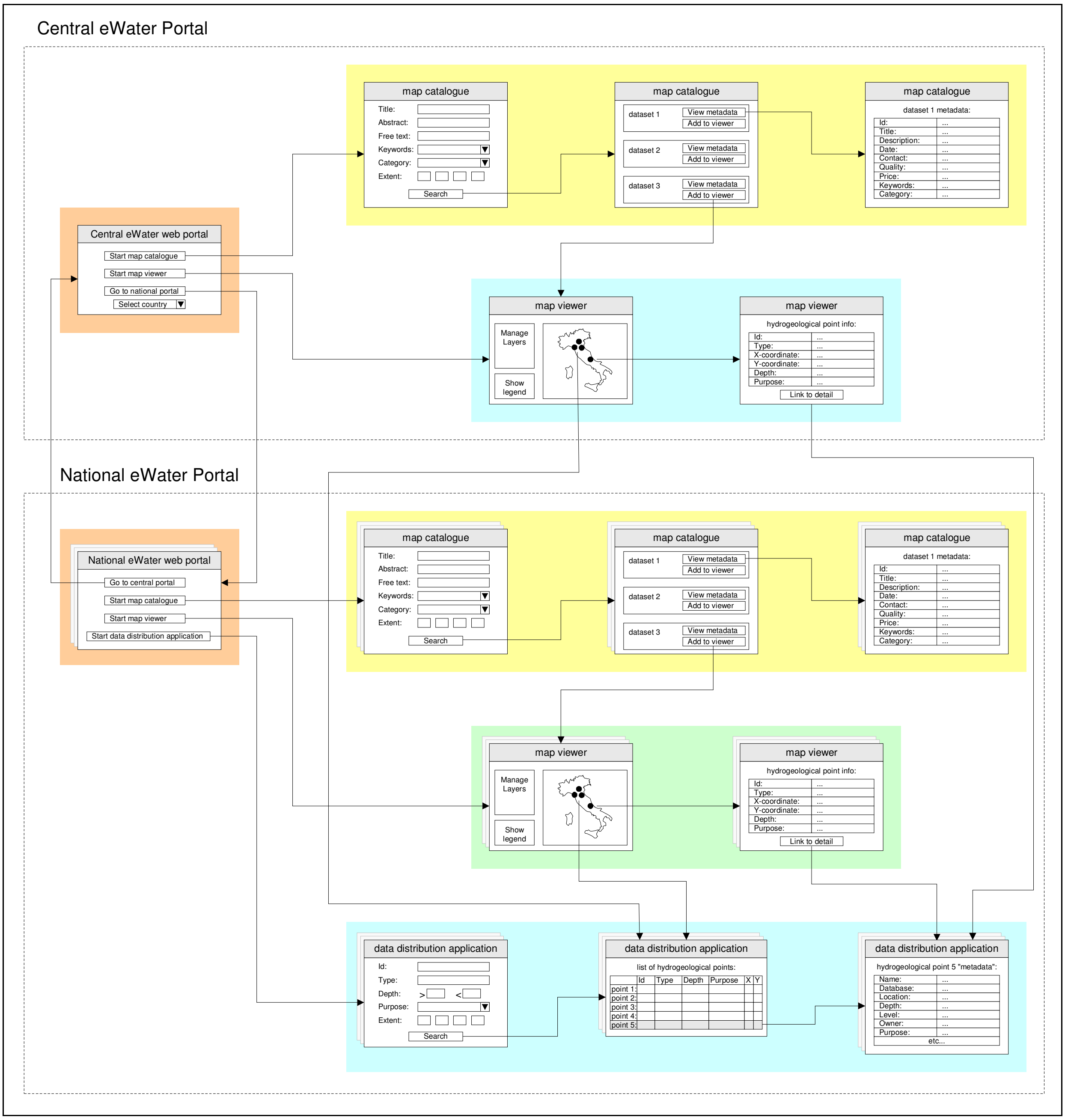

Figure 6: The workflow of eWater system.

The central eWater map metadata catalogue allows direct metadata input as well harvesting the metadata from the national metadata catalogues that are implemented by means of different software. A special procedure was defined in order to organise the collection of the metadata from the different partners of the consortium in compliance with the INSPIRE European directive.

A eWater map viewer allows access to the data that can be taken directly from the catalogue. We organized the displayed maps in different categories to distinguish background layers and thematic ones for each partners. For wells, springs and multi-hydropoints further information can be delivered through the data distribution application, from selections done by the user on the map viewer.

It is important to emphasise that in order to implement the eWater functionalities (including multilingual user interfaces and data search) we had extensively customised the original software products. Comprehensive testing, combined with significant reviewing of the original code, was required to insure that the quality of the final product would correspond to the high standards applied for EC-funded projects.

Data distribution application

In order to request well data from the GIS viewer a user has to select the wells and call the central data distribution application. The data distribution application allows visualisation of the well metadata as well as hydrogeological measurement records. The data is delivered to a client as HTML pages translated in to the language selected by the user. Each HTML page is generated either from an xml file, containing the definition of the search form, or from the xml, containing well data that is returned by the corresponding national web service. The xml files are transformed into HTML be means of XSLT.

Figure 7: search form and web detail form of the data distribution application

In some countries where the information system related to groundwater already existed, specific interfaces were implemented in order to connect the eWater portal with the national databases and to deliver data in the common XML eWater denominator.

eWater-Mobile

A special eWater-Mobile application was implemented in order to enable water specialists, operating in the field, to check well locations and groundwater measurements by means of a mobile handheld computer (UMPC in combination with GPS).

First the mobile application functional and non-functional requirements were derived from the user requirements. The main functional requirements are visualisation of well- and user location on an interactive map and selection of wells. The most important non-functional requirement was to run on a laptop. Therefore the application is focused on Windows based Ultra Mobile PC's making it portable to laptops. Furthermore this gave additional possibilities to use advanced techniques to enhance the usability and performance of the application. The

implementation of the user interface is carried out using Microsoft WPF techniques and is fully multilingual. In order to connect the application to the eWater infrastructure the central eWater catalogue is used to find the eWater services (WMS, WFS and Data Distribution Service) of the different partners. The WMS client implementation is based on the open source SharpMap library. SharpMap has been extended to support tiles for WMS requests which greatly improve the performance of maps on mobile devices. Furthermore support for WFS, GML and GeoRSS has been added to SharpMap in order to fulfill specific requirements. These improvements of SharpMap have been contributed to the SharpMap project.
Well data is retrieved in XML format from the data distribution service and subsequently visualized either in tabular format or in graphical form.
The eWater-Mobile application provides a user-friendly and powerful system (figure 8) to enhance the effectiveness of mobile water specialists.

Figure 8: screen of eWater Mobile application

CONCLUSIONS

The eWater project took advantage of the broader trend in Europe to promote the harmonization of subsurface data repositories and services. The implementation of the multilingual web-based geo-data services provided by eWater project resulted in:

1. Increasing of interoperability of water resources information produced by national organisations at the European level.
2. Easier data exchange between national and regional water resources management agencies
3. Easier problem solving of cross-border water management issues.

4. Better understanding of the needs, problems and procedures to accomplish with the requirements on information resulting from the implementation of the Water Framework Directive
5. Strengthening the partnership between hydro/geo data suppliers and the data users in the EU member states, by advancing in the harmonisation of metadata on spatial hydrogeological information and providing the data access service via the Internet
6. Direct, time saving access to different hydrogeological data sources.
7. Stimulation of the international hydro/geo data and information market via development of practical means for re-use of the hydrogeological spatial data throughout Europe.

eWater project also contributed to the implementation of the European Water Framework Directive (WFD) for river basins and groundwater bodies as well as INSPIRE guidance regarding improvement of accessibility of geo-environmental data to the public. The project motivated the participating Geological Surveys further updating their technical and scientific capacities to meet the new demands from society regarding knowledge infrastructure in Earth Sciences, a task that Geological Surveys have been performing during an average of more than 100 years.

ACKNOWLEDGMENTS

We would like to thank the EC eContent Plus program for funding the eWater project. Also we acknowledge the support given by the European geological surveys and institutes in sharing their knowledge and IT experience.