# Use of modern databases coupled to modelling and mapping tools in groundwater studies

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Reliability and validity of hydrogeological studies depend on the availability of large volumes of high-quality data. The data should be organized in clear structures. The most common way of data structuring is to conceive conceptual models of hydrogeological data and implement them in specialized database management systems. Management, manipulation, and access to hydrogeological information depend principally on these applied conceptual models of hydrogeological data. They require specific languages, terminology and notation based on the information and geomatics concepts. The commonly accepted methodologies and languages are for instance the entity-relationship diagrams or the Object-Oriented UML standard notation, the latter being developed by international consortia and standardisation organisations dealing with geospatial information (ISO/TC211 and Open Geospatial Consortium). The conceptual models expressed in entity-relationship diagrams are easy to implement in many kinds of popular and well known environments (RDBMS). An Object-Oriented approach for the design of geospatial database has more advantages. When explored and applied by geospatial analysts, it allows interoperable data exchanges between different project actors. Such models are easily extensible and adaptable, when they are well structured.

Knowing that all that information is spatially and temporally distributed, it is necessary to use computerised application assistance in data analysis and integrated water management. In cartography, and especially in modern hydrology and hydrogeology research fields, the use of geoinformation systems (GIS) is more and more common. These systems include different components, such as data, hardware, software, procedures, operators and analytical problem statement. By using a database linked with a GIS project, maps based on database attribute queries, such as time- and space-dependent parameter values, can be prepared and visualized. Statistics related to hydrogeological entities can be displayed on screen or printed on supporting maps. Geostatistical procedures (i.e. kriging) can complete the analysis. Some of the tools needed to achieve the objectives are already implemented in the basic software package, but most of them require knowledge of GIS techniques, database philosophy, and specific programming languages.

Many hydrogeological studies and especially integrated water resource management issues need to use physically based numerical models of water flow and contaminant transport. The development of physically based models require large amount of data. A general methodology to manage the data and build the model is one of the crucial tasks and has been developed. The main objectives are to automate as much as possible the development of the models starting from data existing in the database and in GIS project and to allow easy and efficient data handling, updating and modifications in the models. The coupling of geospatial databases, explored under GIS, with numerical model software provides a powerful tool and it is now widely used. This coupling allows easy data processing: pre-processing to prepare data as input for various numerical model parameters and post-processing to display numerical model output.

In conclusion, conceptual modelling of hydrogeological data based on Geomatics concepts, the use of GIS and finally the coupling between databases, mapping and numerical modelling tools facilitate integrated water resources management and information exchange between different actors from all water related domains. Eventually, assimilation within International Spatial Data Infrastructures will be possible.

Possible applications where modern databases are used:
-Walloon Region Hydrogeological Database (E-R):
http://www.argenco.ulg.ac.be/geo3/Hydrogeologie/recherches/banquedonnees_fr.html
-Hydrogeological mapping of Wallonia:
http://environnement.wallonie.be/cartosig/cartehydrogeo/
-GABARDINE, European project: http://www.gabardine-fp6.org
-Groundwater Modelling: http://www.argenco.ulg.ac.be/geo3/Hydrogeologie/