Hydrogeological cartography as a tool supporting water management, spatial planning and environmental protection

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A b s t r a c t. Hydrogeological cartography, intensively developed in Poland over the last several years, is an essential tool for conducting hydrogeological, economic and environmental analysis of the conditions of groundwater occurrence, undertaken for designing new projects and hydrogeological investigation, design work and hydrogeological studies, looking for areas with particularly favorable conditions for the recognition of groundwater, hydrogeological regionalization for economic needs, planning groundwater monitoring locations, assessing quantitative and chemical status of groundwater, planning and developing programs for the protection of groundwater.

Cartographic data produced using digital GIS techniques, are the primary resource for information about the conditions of groundwater occurrence, together with their quantitative and qualitative characteristics. Information gathered in the database of Hydrogeological Map of Poland (MhP) is necessary for preparing analyses by the Polish Hydrogeological Survey, such as status assessments, forecasting changes in groundwater quantity and quality and identifying threats to groundwater resources.

Keywords: *hydrogeology, cartography, water-bearing structures, water management, protection of groundwater resources*

Hydrogeological cartography in Poland has been developing intensively since the 1950's in the form of general serial maps covering the territory of the entire country. This included a 2-sheet map titled *General hydrogeological map of Poland* in the scale of 1 : 300 000, with borehole logs (Kolago, 1955–1968), and thematic maps produced in smaller scales, which were being produced in the 60's and 70's as part of a project aimed at documenting mining areas and large groundwater intakes in Poland. These works were carried out to fulfil the current national needs of Poland with respect to urban economy, implementation of hydrotechnical investments as well as fulfilling water needs for human consumption, agriculture and industry. The first synthesis of the groundwater occurrence and productivity of water bearing layers was presented in the *Atlas of fresh groundwater resources and their exploitation in Poland*, prepared in the scale of 1 : 500 000 (Malinowski, 1976).

The next stage in the development of multisheet cartography in Poland was the creation of the *Hydrogeological map of Poland* in 1: 200 000 scale, including an *Explanatory text*, which was produced in the 80's by the Polish Geological Institute. The recognition of hydrogeological conditions of Poland was summarised between 1993 and 1995 in the *Hydrogeological atlas of Poland* in the scale of 1 : 500 000 (Paczyński, 1995). A programme unique in the European scale aiming at an initial identification of hydrogeological conditions for defining the Major Groundwater Basins (MGWBs) and their protection zones was undertaken in the 80's (Kleczkowski, 1990). The Major Groundwater Basins are considered the most valuable groundwater resources for human consumption in Poland.

A new period in the development of Polish hydrogeological cartography started in 1994, after establishing the new regulations. Based on this legislation, the process started of documenting disposable groundwater resources within balancing units, comprising both surface water and groundwater resources, and documenting hydrogeological conditions in order to define protection zones for MGWBs. Works included creating thematic maps in scales of 1 : 25 000 –1 : 100 000 which comprised information that was defined by the legislator in specific executive legislations and methodological guidance documents.

Finally, between 1996 and 2004, as the major venture in the history of Polish hydrogeology, the first edition of the multisheet *Hydrogeological Map of Poland* (MhP) in the scale of 1 : 50 000 (1069 sheets) was produced using digital GIS techniques. The map presents information on hydrogeological conditions of Poland including the occurrence, hydrodynamics and vulnerability of useful aquifers with a broader interpretation of the Major Useful Aquifer (MUA) within a given hydrogeological unit (Herbich & Sadurski, 2003).

Polish accession to the EU in 2004 set new challenges to Polish hydrogeological cartography, including establishing conditions of occurrence and hydrogeological properties within the First Aquifer and creating an integrated GIS map – *Hydrogeological Map of Poland* – as a tool for implementing the *Water Framework Directive*.

For that reason in 2004, under the auspices of the Polish Geological Institute (PGI), extensive cartographic and IT works started aiming at the digital binding of all MhP sheets, production of new thematic layers on characteristics of the First Aquifer and a systematic updating and verification of information gathered in the MhP's GIS database.

As part of these works, resulting from the need for documenting groundwater vulnerability to anthropogenic pressures, including intensive fertilising by agriculture, in 2005, by the order of the Ministry of the Environment, a general *Groundwater Vulnerability Map in the scale of 1 : 500 000* (Witczak, 2005) was prepared. Since 2006 works have been carried out in the Polish Geological Institute to develop another thematic layer within the MhP's GIS database, which characterises groundwater vulnerability and groundwater quality of the First Aquifer.

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At present, the Polish Hydrogeological Survey is during the 1st cycle of updating the hydrodynamics of the Major Useful Aquifer and/or the First Aquifer as well as verifying available information regarding building structures that can harm groundwater quality and/or quantity.

In parallel, individual layers of the first aquifer of the MhP map are continuously being produced. Works on making the map available through the internet, using WMS and WFS services, are ongoing. In March 2010, works began on a synthesis of thematic layers of the MhP map in the GIS format, adapted to the scale of 1 : 250 000.

Content of the GIS database of the *Hydrogeological Map of Poland* in the scale of 1 : 50 000

General information. The *Hydrogeological Map of Poland* in 1 : 50 000 scale is a serial, thematic, digital map, constructed as a multisheet edition, prepared according to an instruction that has been authorised by the Ministry of the Environment. Its production started in 1996. The Polish Geological Institute, as the general contractor for the project, is responsible for coordinating the venture, in which individual sheets of the map are prepared by different authors employed by geological companies or universities. The work is being prepared by the order of the Ministry of the Environment and the entire project is funded by the National Fund for Environmental Protection and Water Management.

The Polish Geological Institute – National Research Institute has scientific custody over the project and is responsible for the coordination and verification of individual sheets prepared outside the institute and then for inputting all sheets into an integrated GIS database. The Institute also participates in producing several sheets of the map. The high scientific standards of the map are controlled by a special committee (Commission for Cartographic Documentations), which acts under the Minister of the Environment and its duty is to undertake reviews or to assign reviewers for individual sheets of the map and then to hand over these reviews to coordinators of the MhP project in the PGI.

Since 2005, after creating a spatially continuous GIS database for the MhP and after starting works on their systematic improvement and the development of thematic layers, the map comprises two major groups of thematic layers (including cartographic presentations) referring to the Major Useful Aquifer (MUA) and the First Aquifer (FA), i.e.:

1. Developed between 1996 and 2004 thematic layers presenting the occurrence of the MUA, its thickness and transmissivity, groundwater dynamics and yields, groundwater quality, the degree of risk to groundwater pollution. The MUA is treated as the major source of water for human consumption (Fig. 1);
2. Successively developed since 2005, thematic layers characterising the FA, with a special attention given to its interactions with surface waters and terrestrial ecosystems, which is being realised in two thematic groups:
   – occurrence and hydrodynamics (FA-OH);
   – groundwater vulnerability and quality (FA-VQ).

The major useful aquifer is the first aquifer from the ground surface which is commonly used for groundwater abstraction by wells characterised by the following threshold conditions: thickness of a water bearing layer $M > 5$ m, transmissivity of $T > 50 m^2/24h$, potential water yield $Qp > 5 m^3/h$, groundwater quality appropriate for communal use (in the Carpathian and the Sudeten Mountains these threshold levels are lower: $M > 2$ m, $T > 25 m^2/24h$, $Qp > 2 m^3/h$). The identified MUA within a given hydrogeological unit is the fundamental water bearing structure used for supplying water for human consumption.

The first aquifer is the first water bearing horizon below the ground (or set of hydraulically connected aquifers), with average permeability of $k \geq 3$ m/24h ($k \geq 3 \cdot 10^{-5}$ m/s), total thickness $M \geq 2$ m (in moderate retention conditions) occurring continuously usually over an area of $A > 20 km^2$ (with accuracy of recognition typical for 1 : 50 000 scale).

Thematic layers of the MhP's GIS database – characteristics of the Major Useful Aquifer (MUA). Characterization of the MUAs as presented on the *Hydrogeological Map of Poland* in 1 : 50 000 scale includes the following elements:

- ❏ hydrogeological parameters of an aquifer required for defining hydrogeological regions and include: the extent, age, lithology, isolation from the ground surface, the coefficient of disposable resources and information on the coexistence of multiple water bearing layers of usable waters;
- ❏ hydrogeological and spatial properties: transmissivity, thickness, depth to an aquifer, potential yield of a well;
- ❏ hydrodynamics: hydroisohips, direction of groundwater flow, cones of depression, the extent of river basins defined by surface water catchments;
- ❏ groundwater quality classes defined by an assessment of their usability for human consumption;
- ❏ point pollution sources that influence the degree of groundwater vulnerability;
- ❏ groundwater management (information on locations of industrial and draining groundwater wells including data on hydrogeological profiles, technical specifications of wells, admissible volumes of extracted groundwater and abstraction rates).

Groundwater availability of the Major Useful Aquifer is presented on the MhP in the form of a coefficient of disposable groundwater resources and is a component of a specific record associated with a given unit of the MUA. Groundwater disposable resources can be classified within 6 classes (50–100, 100–200, 200–300, 300–400, 400–500, >600 $m^3/24h \cdot km^2$) and are established based on hydrogeological documentations and regional reports. The coefficient acknowledges numerous factors including the degree of isolation for a specific MUA, limitations associated with threats to groundwater resources and a requirement for protecting terrestrial ecosystems dependent on groundwater resources.

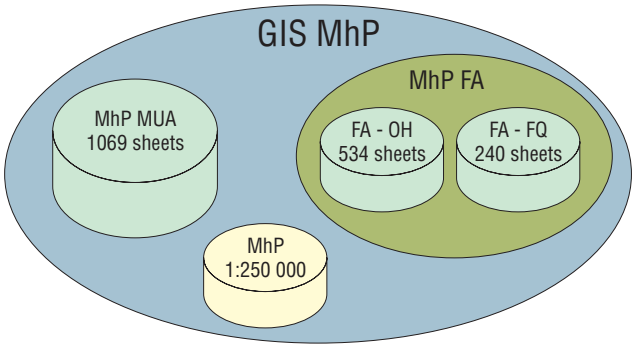

Fig. 1. Thematic layers of the GIS database of the *Hydrogeological map of Poland* (MhP) – explanations in text

Potential yield of a well abstracting from the MUA is defined as the maximum yield that is available for abstraction with an optimum well-screening, i.e. with conservation of a critical velocity of water entering the well-screen. The parameter is presented on the MhP map within the following ranges: 2–5, 5–10, 10–30, 30–50, 50–70, >70 m^3/h or 70–120 and >120 m^3/h.

Groundwater quality of the MUA can be classified on the MhP map as very good, good, moderate and bad and is based on an assessment of its usability for municipal supplies, i.e. water that does not require any treatment, water that requires little treatment, water that requires a complex, multistage treatment and water that is not available for treatment using economically justified technology; on the main sheet of the map there is also information on where specific parameters are exceeded with respect to water quality regulations destined for human consumption as defined by the Ministry of Health.

Degree of isolation of the MUA is a component that is defined based on the thickness of low permeability deposits ($k = 10^{-6}$–10^{-9} m/s) and practically impervious deposits ($k < 10^{-9}$ m/s) overlaying the MUA. Low isolation of the MUA is defined for conditions where the thickness of low permeability units is less than 15 m or impervious units are less than 5 m; moderate isolation is given when low permeability deposits range between 15–50 m or the thickness of impervious units is between 5–10 m; and finally full isolation is defined for conditions of the thickness of low permeability deposits exceeding 50 m and the thickness of impervious deposits exceeding 10 m. This classification incorporates also a potential for lateral inflow and the type of an aquifer, i.e. whether is it porous or fissured.

Degree of groundwater vulnerability within the MUA can be defined as very high, high, moderate, low and very low and is a function of the degree of isolation, density of polluting sources (increasing groundwater vulnerability in conditions of the same degree of isolation) and limitation in land use for business (decreasing groundwater vulnerability in conditions of the same degree of isolation).

Apart from that, additional thematic maps include information on the depth to the MUA, its thickness and permeability.

The map was created in sheets (1069 sheets for the entire territory of Poland) and each sheet includes:

- ❏ a main sheet presenting the occurrence, extent, quantity, dynamics, quality and the degree of risk to fresh groundwater **(example of map sheet shown in Annex No. 1)**[3];
- ❏ a report including hydrogeological cross-sections, figures and tables that include characterisation of groundwater abstraction points, groundwater quality data, hydrogeological parameters for delineated hydrogeological units and information on infrastructure that cause risk to groundwater resources. Each report includes additional thematic maps: documentation map, thickness map and groundwater permeability map.

Thematic layers of the MhP's GIS database – characteristics of the First Aquifer (FA). The first aquifer is identified and characterised without taking into account criteria for usable aquifers – its properties may exclude a potential for groundwater abstraction (too low thickness or too low transmissivity). Quality of water within the first aquifer, for geogenic reasons or in response to anthropogenic pollution, may not be available for municipal use.

Thematic layers of the MhP's GIS database characterising the First Aquifer (FA) constitute two thematic groups:

- ❏ occurrence and hydrodynamic (FA-OH);
- ❏ groundwater vulnerability and quality (FA-VQ).

The first group comprises information characterising a relationship between first aquifers and major useful aquifers (identity and separation), lithology, permeability, stratigraphy of water bearing deposits, their continuity, water table characteristics, hydrodynamic conditions of the FA (including geomorphology: valleys – drainage zones, uplands – recharge zones, plains and depressions – transitory and diverse zones). The above properties constitute basic factors for delineating hydrogeological regions/units within the first aquifer on the MhP map. Each property has its own symbol. On the MhP map, each FA unit is described by a group of symbols representing different hydrogeological properties specific to a unit.

The collective map presenting the occurrence and hydrodynamics of an aquifer includes hydroisohips and general directions of groundwater flow, depth to an aquifer presented in a range (< 1 m, 1–2, 2–5, 5–10, 10–20, 20–50, > 50), springs, seepages, wetlands, groundwater lenses, extents of depression cones resulting from anthropogenic impacts (over abstraction, mining dewatering, draining wetland areas, urban/industrial infrastructure) and flooding of sinkholes. The map includes also areas in which groundwater level of an FA unit has increased significantly due to anthropogenic causes.

Apart from that, the map shows the relationship between surface waters and the FA (recharging or draining or no relation) and the extent of anthropogenic changes made at the ground surface, which are important for the occurrence of the first aquifer (pits, embankments and sinkholes within mining areas).

Characterisation of the first aquifer includes also information on areas where shallow groundwater is common but it occurs in discontinuous water bearing horizons (layers of sands and sands placed at roofs of boulder clays, lenses of fissured sandstones within flysch shales, disturbed glacitectonic structures). Within units that include the above formations of the FA, hydroisohips are not presented and depth to the groundwater table is presented in wider ranges.

In specific, hydrogeologically sound cases, information about lacking water bearing horizons is also presented.

The second thematic group of layers defines groundwater vulnerability of the FA to a potential pollution from the ground surface and groundwater quality (Herbich, 2004; Herbich et al., 2007).

Groundwater vulnerability classes present an approximate time needed for pollution to be transferred to the first aquifer, based on a mean residence time (*MRT)*, which is the average amount of time that a particle spends in a particular flow system. Based on a spatial analysis of the *MRT*, the first aquifer is assigned to one of 5 vulnerability classes: very high, high, moderate, low and very low (respective *MRT* < 5, 5–25, 25–50, 50–100 and > 100 years). Groundwater vulnerability to pollution of the FA is presented on the collective map in association with the extent and hydrogeological properties of an aquifer only, without acknowledging properties of contaminants, their type, dispersion,

[3] *Hydrogeological Map of Poland,* 674 – Dęblin sheet (attached)

sorption and disintegration processes, as well as temporal variability of hydrogeological events that control groundwater infiltration (Herbich et al., 2008).

The thematic map *groundwater quality* presents concentrations of nitrates and other selected parameters within the first aquifer including SO_4, Cl, NO_2, NH_4, pH and PEW. Spatial analysis of nitrate concentrations constitute a basis for defining areas where groundwater is polluted with nitrates ($NO_3 > 50$ mg/dm^3) or is at risk to nitrate pollution ($25 < NO_3 < 50$ mg/dm^3). Groundwater vulnerability and quality of the FA is presented on collective maps including polluting sources, which are building structures and anthropogenic activities that can deteriorate chemical status of the first aquifer.

Structure and digital format of the MhP's GIS database. Implementation of the geographic information systems (GIS) technique enables the undertaking of cartographic presentations, the undertaking of spatial analyses within a selected area and the continuous updating of graphical and textual databases. To fulfil the needs of the *Hydrogeological Map of Poland*, a special GIS environment was designed and later built in the Polish Geological Institute, which enabled the undertaking of essential tasks such as gathering graphical and textual data, data verification, renaming digital data into a cartographic form, map printing and data storage.

The production of thematic layers of the MhP's GIS database in the PUGW 1942 reference system was finalised in 2004, and later new works started on developing a spatially continuous database of hydrogeological data. The integrated MhP's GIS database has been created in the PUWG 1992 reference system, which enables the presention of all thematic layers for the entire Polish territory in the same mapping system. After completing the MhP's GIS database, further works focused on data management, their revision and dissemination.

Storing data in the GIS format allows data stored in different structures to be merged without interference with raw data. The functionality of the environment in which the MhP's GIS data are collected and presented allows also other data created in the same software to be used and data created in different software environments to be imported (Fig. 2).

The geographical information system allows also the incorporation of additional thematic layers into the parent database. Thematic groups that are being continuously developed include characterisation of the first aquifer created in separate sheets and are then incorporated into the MhP's GIS database.

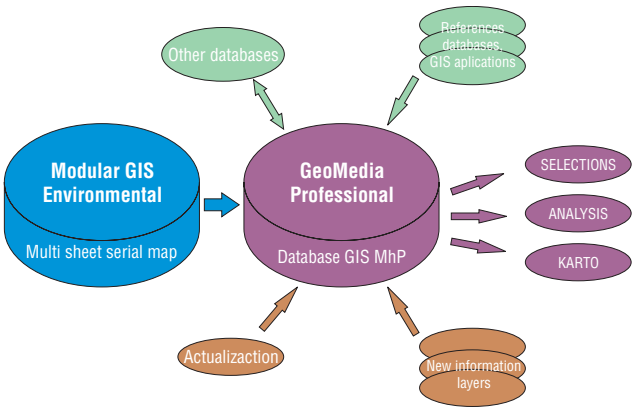

Fig. 2. Functionality diagram of the MhP's GIS database

An important element of using the GIS system is that it allows the distribution of selected data via the internet. At present work is being carried out to publish selected thematic layers via net services of WMS and WFS using the PGI geoportal (web addresses are available at the PSH webpage). The present format and structure of the database allow specific thematic layers to be selected within an arbitrary area, e.g. within a district, or balancing unit, basins or other (Fig. 3).

Current state and availability of the multisheet edition of the *Hydrogeological Map of Poland*. Thematic layers regarding the Major Useful Aquifer have been completed for the entire country; the state of relevance of the thematic layers corresponds to the times when specific sheets were completed (Fig. 4). Thematic layers characterising the hydrodynamics of the MUA and the First Aquifer are updated every 6 years. The first updating cycle started in 2009.

Thematic layers regarding the occurrence and hydrogeological properties of the First Aquifer have been completed for 534 sheets of the MhP map; at present, 150 consecutive sheets are being prepared, which will be completed in 2011 (Fig. 5A). Layers: groundwater vulnerability and groundwater quality of the first aquifer are in the initial stage of processing and until now only 240 sheets have been completed (Fig. 5B).

Thus, for some 23% of the country, the MhP's GIS database includes the full characterisation of hydrogeological conditions that allows protection areas to be delineated for groundwater intakes and groundwater aquifers and enables spatial planning. The hydrogeological information required for defining mitigation measures for groundwater dependent terrestrial ecosystems is available for some 65% of the country. Basic data for designing geological works and undertaking tasks of water management are available for the entire country.

The use of the MhP's GIS database for water management, spatial planning, environmental protection and geological works

The *Hydrogeological Map of Poland* in 1 : 50 000 scale is the basic cartographic documentation for undertaking hydrogeological, economic and environmental analyses regarding the occurrence of fresh groundwater resources, undertaken for designing new projects and hydrogeological investigation, searching for areas especially useful for abstracting groundwater, hydrogeological regionalisation for economic needs, planning groundwater monitoring locations, assessing groundwater quantity and quality, spatial planning and defining programmes for protecting groundwater resources. An important use of the utilisation of the MhP's GIS database in hydrogeological projects is identification of the occurrence of groundwater for designing groundwater supplies and their protection zones and undertaking environmental assessments with regard to designing abstraction points.

Information gathered in the database is necessary for preparing analyses by the Polish Hydrogeological Survey, such as, status assessments, forecasting changes in groundwater quantity and quality and identifying threats to groundwater resources.

The MhP database constitutes also a source of hydrogeological information required for preparing hydrogeological documentations for river basin management plans as

well as planning documents regarding conditions for water use within a hydrogeological region or a basin. Specifically, these are as follows:

- ❏ registers and characterisations of groundwater bodies, including groundwater bodies that are at risk of not fulfilling their environmental goals;
- ❏ identification of significant anthropogenic impacts and assessments of their effects on groundwater resources;
- ❏ identification of impacts resulting from changing water levels;
- ❏ registers of protected areas;
- ❏ economic analyses referring to water use;
- ❏ groundwater monitoring programmes;
- ❏ registers of groundwater used for human consumption;
- ❏ registers of groundwater that could potentially, either in the future or in the event of special events (disasters, terror attacks, wars) become a source of potable water;
- ❏ registers of water vulnerable to nitrate pollution from agricultural pressures;
- ❏ definition of environmental objectives for groundwater bodies and protected areas.

The MhP's GIS database can be used for undertaking the following analyses:

- ❏ delineating water balancing units for defining disposable groundwater resources and undertaking groundwater management programmes;
- ❏ defining hydrogeological conditions for delineating critical protection areas for the Major Groundwater Basins;
- ❏ identifying areas of especially good conditions for locating large and medium groundwater supplies;
- ❏ designing groundwater supplies and their protection areas;
- ❏ defining hydrogeological conditions of protected areas;
- ❏ assessing anthropogenic risks to groundwater quality; assessing groundwater status and defining programmes of measures for the protection of groundwater resources;
- ❏ defining development strategies and spatial planning documents;
- ❏ providing third level education.

The *Hydrogeological Map of Poland* in the scale 1 : 50 000 is available through the Central Geological Archives based in the Polish Geological Institute – National Research Institute in Warsaw, 4 Rakowiecka Street. The map is available in an analogue format (as a printout of a given sheet) or in a digital format (as raster or vector files including spatial

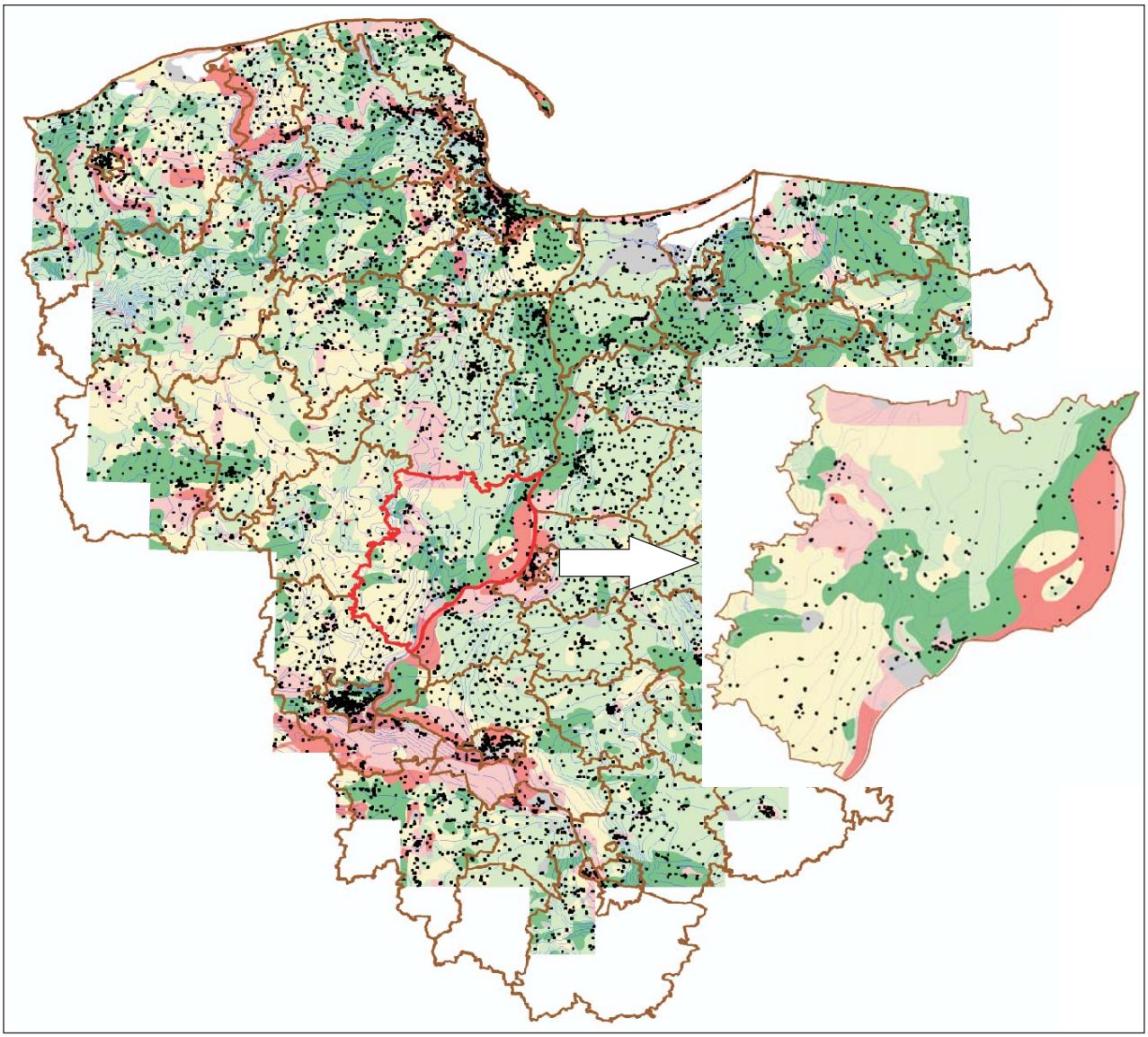

Fig. 3. Fragment of an integrated MhP's GIS database – possibility of selecting attributes within defined boundaries

information for a given area, a map sheet or selected groundwater body, a basin or within administrative units, etc.). The extent of an area of interest, thematic layers and the data format are agreed individually between a client and coordinators of the map. Specific rules for data distribution and data request application forms are available at the PGI web page (www.pgi.gov.pl).

Groundwater susceptibility map in the scale of 1 : 500 000

Groundwater susceptibility to pollution, called also the groundwater vulnerability map, constitutes an important aspect of the groundwater quality assessment required for compiling water management plans within river basins and local development plans. There are numerous methods for assessing groundwater susceptibility; however, the most common are ranking methods, which attribute a weight to specific parameters (DRASTIC, DIVERSITY, EPIK and other). Polish experience shows that instead of using a ranking based on many parameters, the mean residence time (MRT) can be used as a synthetic quantitative indicator of natural groundwater vulnerability to pollution (Witczak et al., 2005, 2007, 2008).

Classification of groundwater vulnerability to pollution based on Foster et al. (2002) modified by Witczak et al. (2005, 2008) is shown in Table 1.

In order to fulfil requirements of the *Water Framework Directive*, in 2005, by the order of the Ministry of the Environment, the *Groundwater Vulnerability Map* in the scale of 1 : 500 000 was completed, edited by Witczak. The map included an assessment of groundwater susceptibility of the First Aquifer (sheet 1 – **the map shown in Annex No. 2**)[4] and the Major Groundwater Basins (sheet 2). According to the approved methodology, groundwater susceptibility classes were assessed based on the mean residence time of the water (volumetric humidity) – average seepage time through soils and rocks at the aeration zone. The time given on the map refers to the exchange time within a natural hydraulic cycle with an assumption of the mean annual infiltration (Witczak et al., 2005).

The methodology used on the 1 : 500 000 scale map allows the undertaking of further assessments depending on assumed impact scenarios with regard to specific polluting substances, or different land use and land management practices (Witczak et al., 2005, 2007, 2008). The methodo-

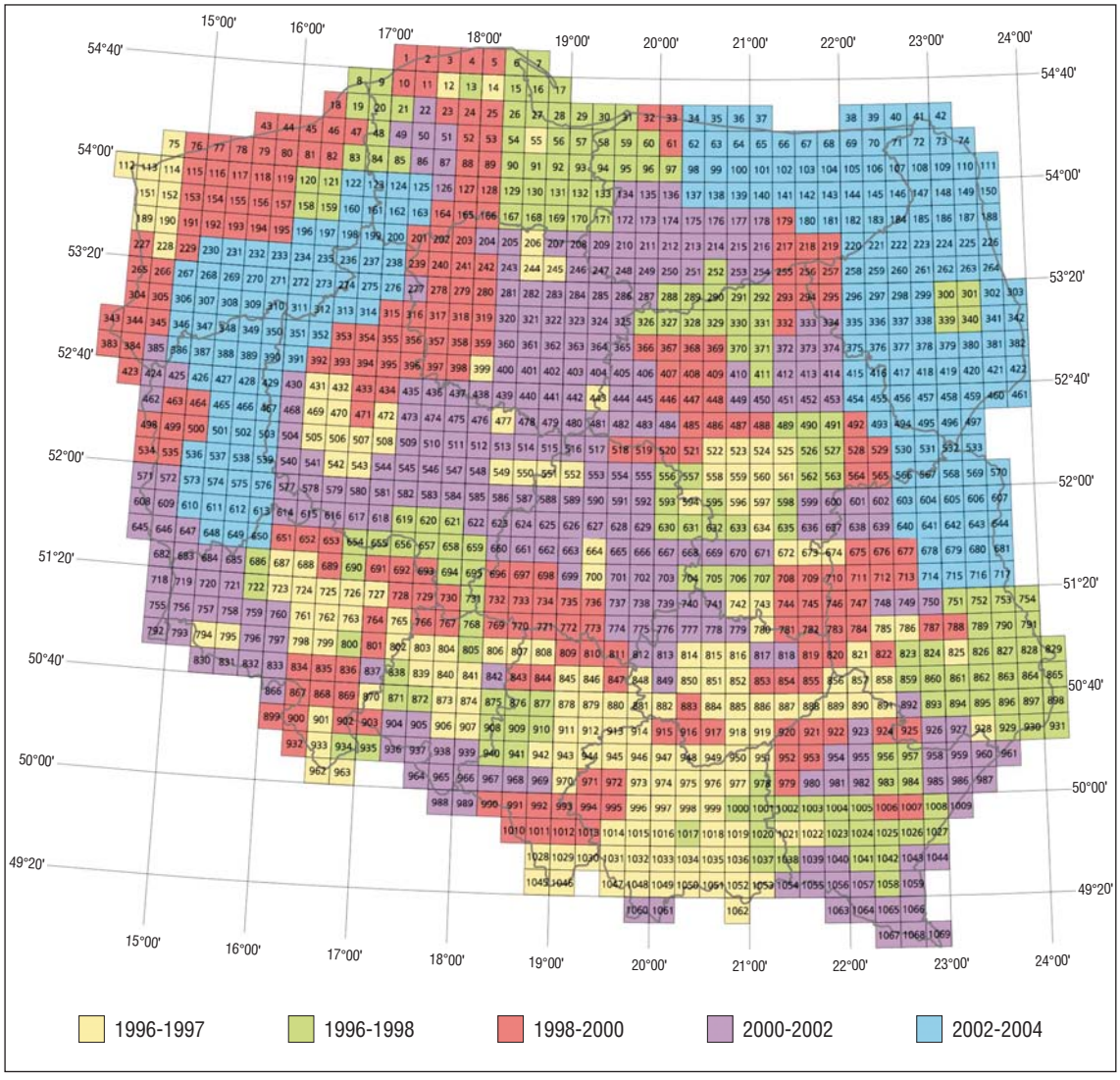

Fig. 4. State of relevance of the *Hydrogeological Map of Poland* in the scale of 1 : 50 000 – characterisation of the Major Useful Aquifer

[4]*Groundwater Vulnerability Map of Poland* (attached)

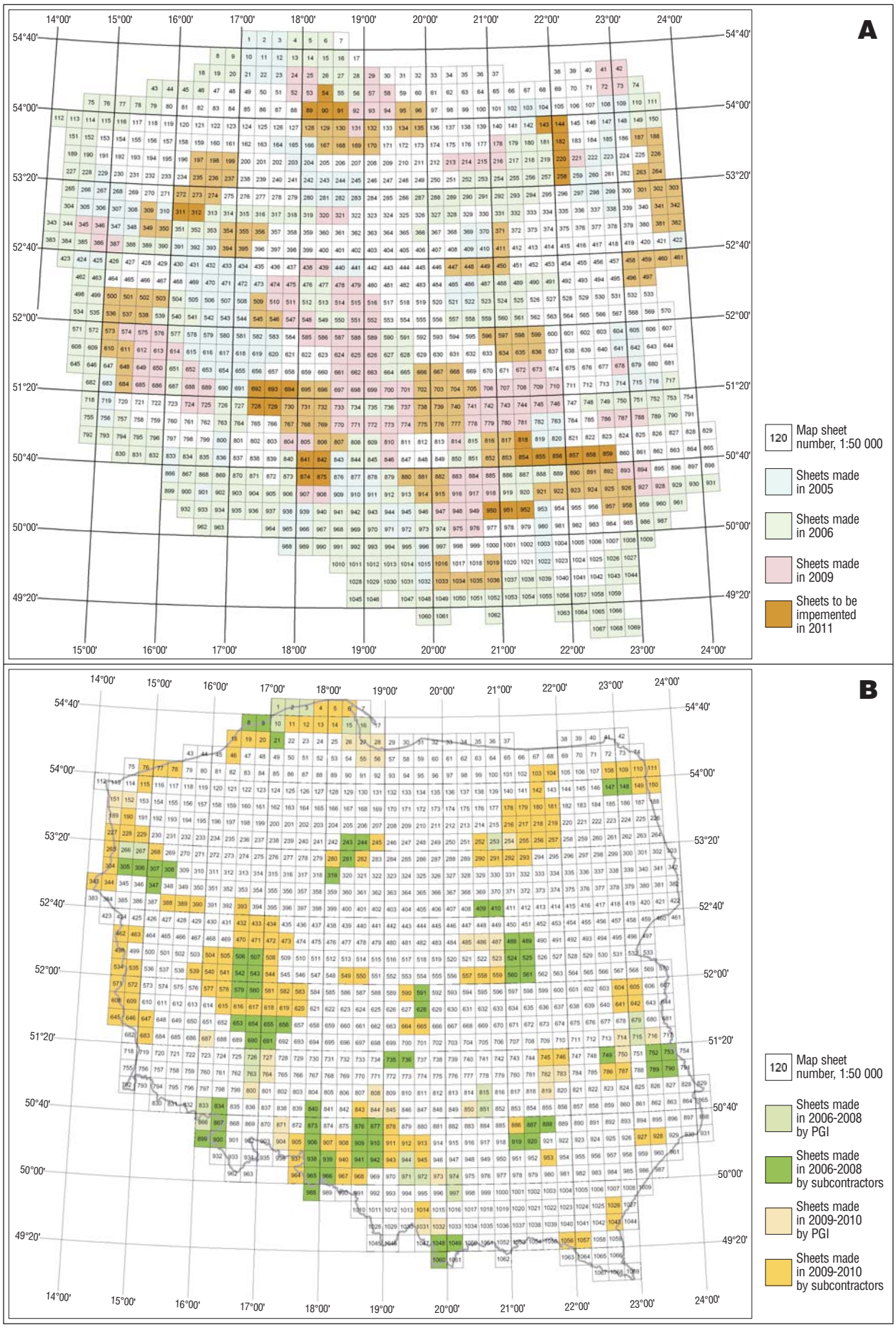

Fig. 5. Current state of work on thematic layers of the First Aquifer: **A** – occurrence and hydrodynamics; **B** – groundwater vulnerability and groundwater quality

Table 1. Part of the legend of Groundwater Vulnerability Map with shallow groundwater vulnerability classification

Class code	Colour on the map	MRT – estimated Mean Residence Time of water in vadose zone [years]	Groundwater vulnerability to pollution	Vulnerability characteristic after Foster et al. (2002) modified referring to the MRT
1		<5	Very high	Aquifer vulnerable to most water pollutants with rapid impact in many pollution scenarios
2		5-25	High	Aquifer vulnerable to many pollutants, except those strongly absorbed or readily transformed in many pollution scenarios
3		25-50	Moderate	Aquifer only vulnerable to some pollutants, but only when continuously discharged or leached
4		>50	Low and very low[a)]	Aquifer only vulnerable to conservative pollutants in the long term when continuously and widely discharged or leached. Aquifer confining beds present with no significant vertical groundwater leakage

[a)] *in fissured, fissured–karstic and fissured-porous rocks a faster transport of the part of contamination (generally <10%) is possible by preferential flow paths in periods of intensive precipitation. It should be included in detailed risk assesment scenarios.*

logy was used for compiling the Groundwater Vulnerability Map of the first aquifer in the scale of 1 : 50 000.

Hydrogeological Map of Poland in the scale of 1 : 250 000

The map, which has been under development since this year, will be a synthesis of all work focused on defining hydrogeological conditions of usable groundwater, its properties and relationship with surface waters and groundwater dependent terrestrial ecosystems, including cartography in the scale of 1 : 50 000 that has been carried out in Poland since 1996. The map will be prepared in the scale of 1 : 250 000 and will include a characterisation and the general groundwater status assessment as required by reporting for the *Water Framework Directive* and the preparation of River Basin Management Plans and other documents regarding the development strategies for the country and individual provinces.

The map will be used in research and regional and national planning documents and for teaching purposes in research and academic centres. The map will also be used for disseminating hydrogeological issues among the public by the Polish Hydrogeological Survey, National and Regional Water Management Authorities.

The first phase of work is planned for 2010. Within this phase, thematic assumptions of the map including compilation of an instruction for the map and a schedule of work for preparation of individual sheets will be made. All organisational aspects of the project will be agreed at this stage including the detailed concept of thematic layers, their graphical presentation, structural assumptions and the work schedule. The concept of thematic content of the map will meet the requirements of the INSPIRE *Directive* with respect to publishing cartographic materials.

Summary

The development of hydrogeological cartography in Poland has been influenced by many factors over the past few dozen years, including economic, social and political factors. The economic situation of the country and the social structure laid out a direction for development in thematic hydrogeological cartography. By delivering complex information regarding the current state of understanding of the national and local hydrogeological conditions and their potential use, Polish hydrogeologists have been continuously answering the needs of the society and the national economy.

Since the 1990's Polish hydrogeological cartography has been developed as a database, treating cartographical presentations as a visualisation of selected thematic components. This strategy resulted in a sudden increase in serial thematic maps that were integrated within GIS databases with a possibility of making them available in a digital format.

Requirements of the EU, especially the EU *Water Framework Directive*, the *Groundwater Directive* and the INSPIRE *Directive* set new challenges to Polish hydrogeology, including the compilation of a synthesis of the *Hydrogeological Map of Poland*, which will be used for developing strategic documents regarding the national water management. In parallel, an increasing social awareness of groundwater issues in Poland requires the collected groundwater data to be disseminated in formats that thanks to the INSPIRE *Directive* are now standardised.

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