

# Hydrographic Information Systems and Cartography in Poland

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**Key words:** hydrography, GIS, cartography, Poland

## SUMMARY

Among the more important spatial information systems concerning cartography we may distinguish those dealing with environmental monitoring, geological map of Poland, meteorology and water economy, hydrographic division of the country, swamps and grasslands.

*The Hydrographic Map of Poland (1:50,000)* worked up in both analogue and digital versions (in the 1992 coordinates system) presents in a synthetic way the conditions of water circulation against the background of geographic environment. *The Map of Hydrographic Division of Poland (1:50,000)* is based on the continuous, uniform hydrographic database in the 1992 coordinate system. It includes the set of vector information layers GIS (ArcInfo) with a reference database characterizing the water network. *The Hydrogeological Map of Poland (1:50,000)* has been prepared in the computer system – INTERGRAPH. *The Atlas of Polish Swamps – natural and transformed (1: 300,000)*, in the 1942 coordinate system, contains two sets of thematic maps with legends, index and factual introduction. The information concerning hydrographic conditions may also be found in the *Sozological Map of Poland (1:50,000)* and the *Geological-Economical Map of Poland (1:50,000)*. The hydrographic information serves the implementation of the policy of sustainable development.

## STRESZCZENIE

Do ważniejszych systemów informacji przestrzennej dotyczących hydrografii należą systemy dotyczące: monitoringu środowiska, mapy geologicznej Polski, meteorologii i gospodarki wodnej, hydrograficznego podziału kraju, bagien i użytków zielonych.

Mapa hydrograficzna Polski (1:50 000) opracowywana w wersji analogowej i cyfrowej (w układzie współrzędnych 1992) przedstawia w syntetycznym ujęciu warunki obiegu wody na tle środowiska geograficznego. Mapa podziału hydrograficznego Polski (1:50 000) oparta jest o ciągłą, jednolitą bazę danych hydrograficznych w układzie współrzędnych 1992. Zawiera zbiór wektorowych warstw informacyjnych GIS (ArcInfo) z relacyjną bazą danych charakteryzującą sieć wodną. Mapa hydrogeologiczna Polski (1:50 000) wykonywana jest w systemie komputerowym INTERGRAPH. Atlas mokradeł Polski – naturalnych i przeobrażonych (1:300 000), w układzie współrzędnych 1942, zawiera dwa komplety map tematycznych wraz z legendami, skorowidzem i merytorycznym wprowadzeniem. Informacje dotyczące warunków hydrograficznych zawierają ponadto: Mapa sozologiczna Polski (1:50

000) i Mapa geologiczno – gospodarcza Polski (1: 50 000). Informacje hydrograficzne służą realizacji polityki rozwoju zrównoważonego.

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## 1. INTRODUCTION

A rational use and management of an area has to be based on a good diagnosis of the state of natural environment resources and the direction of changes that the environment undergoes. To achieve this goal we use databases, spatial information systems and environmental maps concerning different physiographic elements, such as: existing rocks, soil, water, air, plants, etc. The most common numerical data used in spatial planning practice comprise information regarding soils, geology, climate, hydrology, environment monitoring, protected areas, contaminated areas, areas threatened by flooding, etc. The data are mostly obtained from the processed aerial and satellite photographs, in the form of numerical models or numerical ortophotomaps [Koreleski 1997, 1999, 2001] presenting relief, land use structure, etc. Big amount of information comes from the processing of various traditional, (analogue) maps, atlases and studies.

The significance of the information concerning hydrological and hydrographic conditions for Polish economy is special, as the country belongs to the poorest in Europe when it comes to water resources counted per one inhabitant (1,5 thousand cubic meters, with the European mean value of 4,5 thousand cubic meters per person). Central Poland is also liable to a process called “stepping”. Adding to this the not-very-good state of cleanliness of surface water – flowing and stagnant, as well as sea- coastal water – the quantitative and qualitative water resources of the country require a particularly precise monitoring as well as taking adequate preventive measures for the improvement of country’s water balance and management.

This paper presents an outline of the existing Polish spatial information systems and cartographic studies related to the water conditions issues, with special regard to hydrographic aspects.

## 2. DEVELOPMENT OF POLISH HYDROGRAPHIC CARTOGRAPHY

The below presented outline of the evolution of Polish hydrographic cartography bases on the book edited by Paślawski [2006] as well as the author’s own materials.

The first image of the water network of the country had been brought by two maps *The Hydrographic Chart of the Polish Kingdom* (at the scale of about 1: 1,000 000) of 1850 and *The Hydrographic Map of Old Slav Lands; the North-Western Part* (the 1: 2,000 000 scale), of 1882. The next – *Review Hydrographic Map of the Republic of Poland*, at the scale of 1:750 000 appeared only in the mid – war period in 1925.

A review picture of the hydrographic network is presented in *The Polish Land Use Review Map*, 1:1,000 000, of 1957, authored by Uhorczak [1969]. It has been accomplished through photographic diminishing of the chosen elements of a mid-war topographic map at the scale of 1:1,000 000. The obtained surface water picture shows the differentiation of water network density and thus the degree of irrigation of various regions of the country.

The detailed inventorying of Polish water resources was initiated by hydrographic mapping combined with geomorphological mapping. The hydrographic mapping conducted in the years 1951 – 1968 comprised about 19% of the country's area, but resulted in only forty – some two– and three–colour sheets of *The Hydrographic Map of Poland* 1:50,000, mainly from the neighbourhood of Białystok, Toruń and Bydgoszcz (5% of country area coverage). The work on a detail hydrographic map was undertaken again at the turn of the seventies and eighties of the 20<sup>th</sup> century [Galon 1983]. The new map began to appear in 1984 on the foundation of a topographic map of the 1965 coordinate system. For ten years 100 sheets have been published. In 1994 the 1965 coordinate system was for a short time replaced with the 1942 system and then in all civil cartography the 1992 system came into use. The introduction of a vector map (VMap L2) into official cartography in 2004 caused the change of topographic foundation of the hydrographic map.

*The Hydrographic Map of Poland* 1:50,000 has in the course of its 50–year – long history undergone evolution in its content and graphic shape. Initially, it only presented the picture of surface water related to lithology, and point information concerning underground water. A contemporary version of the map shows in a comprehensive way the conditions of water circulation: characterizes surface water and underground water (to the first level), ground permeability, contains also more information about objects and phenomena of water management, e.g. about water quality. The latest changes in the map content are connected with the necessity of adjusting Polish legal regulations regarding environment protection to the requirements of the European Union. The coverage of the country with the hydrographic map amounts to more than 50%. It is being prepared in two versions – analogue and digital. In the fifties and sixties of the 20<sup>th</sup> century the hydrographic map was accomplished by the Institute of Geography of the Polish Academy of Sciences in Toruń and Cracow in cooperation with many other scientific centres. At present it is published by the Head Office of Geodesy & Cartography of Poland, according to the concept worked up by the team consisting mainly of the representatives of the Faculty of Geographic and Geological Sciences of the Adam Mickiewicz University in Poznań, as well as the representatives of other geographical centres and the Poznań enterprises – GEPOL and GEOMAT.

During the break in the work on the 1:50,000 scale map, i.e. in the seventies of the 20<sup>th</sup> century, two important cartographic studies came into being.

The first one is a 57– sheet *Hydrographic Division of Poland* 1:200,000, published in 1980.

Due to its very limited range of content it cannot substitute a detailed hydrographic map of the whole country. It presents the surface water against the background of lithology, whose colours inform about the degree of permeability of individual rocks. To prepare this study topographic maps at the scale of 1: 100,000 and 1: 25,000, as well as a 1: 300,000 – scale geological map have been used.

The view of the surface water phenomena is also included in the *Review Hydrographic Map of Poland* 1: 500,000 from the years 1975 – 1980. The highly detailed presentation of the water network allows us to draw conclusions concerning the geomorphological features of the areas, and the issues described may be related to both the water itself (e.g. the flows) and the accompanying phenomena (the range of catastrophic floods, the areas of significant changes in water conditions caused by anthropopression). The thematic content of the map is accompanied by the detailed, but clear hypsometric foundation. The map has been edited on 11 sheets of two different sizes.

In 1987 appeared *The Hydrological Atlas of Poland* which offers a comprehensive presentation of the country's water resources, their circulation against the background of other constituents of natural environment. For the first time a scale of 1: 1,500 000 has been used as the main scale for the presentation of the most important issues in the atlas of Poland. The atlas includes also a 9-sheet review hydrographic map at the scale of 1: 500,000. The content has been based on the observations from the years 1951–1970. The second book of the atlas contains source data and the descriptions of the map – making methods.

### **3. INFORMATION CONCERNING WATER IN THE SPATIAL INFORMATION SYSTEMS (SIS)**

In the last years one may observe a dynamic development of SIS (GIS and LIS) in management and administration. Such systems make possible conducting automated analyses of any spatial data reduced to the numerical form. The advantage of these systems – as a tool supporting decisions in land development and protection – over traditional studies results from the possibility of current automated assessment of changes occurring in space.

The more important systems of spatial information in Poland concerning hydrography and other water problems comprise [Koreleski 2003, 2005]:

- information system of environmental monitoring (soils, water, air)
- information system for the needs of the *Geological Map of Poland*
- information system for meteorology and water management
- information system for the needs of hydrographic division of the country
- information system concerning swamps and grasslands.

The national environment monitoring system is connected with the European Environment Information and Observation Network (EIONET) which is a branch of the European Environmental Agency (EEA). The Polish EIONET structures comprise, among others, the Chief Inspectorate of Environmental Protection, the Institute of Meteorology and Water Management, the Ministry of the Environment. The EU Census Bureau (Eurostat) collects through questionnaires comprehensive information about water (water management, water protection).

Information systems for the needs of the *Geological Map of Poland* or the *Map of the Hydrographic Division of Poland* serve mainly the preparation of their analogue version.

The intrinsic information concerning water objects, conditions of water occurrence, water circulation and management may also be found in information systems for meteorology and water management, zoology, as well as the information systems regarding swamps and grasslands (SIMUZ – SIP).

Apart from field studies, the processed aerial photographs and satellite images are the basic source of information about water conditions.

#### **4. REVIEW OF MAPS CONCERNING WATER CONDITIONS**

The review below presents the main contemporary cartographic studies (detailed maps and atlases) concerning water conditions, with special regard to hydrographic maps.

*The Hydrographic Map of Poland* (1: 50,000) – in analogue and digital versions – is a thematic map offering a synthetic presentation of the conditions of water circulation against the background of geographic environment. The content of the map includes detailed information concerning:

- topographic watersheds
- surface water
- underground water outflow
- ground permeability
- water management objects and phenomena
- discharge gauging station

The numerical map has been worked up in GIS, which meets, among others, the following requirements:

- has a layer structure (each of the layers contains vector objects from the specified thematic range) as well as a descriptive database
- offers a possibility of exchanging information with other GIS systems
- enables the adjustment of the projection and the system of coordinates of a numerical map to the national system of spatial reference currently in force in Poland
- allows to print the map in the CMYK system
- offers a possibility of combining the neighbouring sheets into bigger vector areas.

The raster foundations of combined situation and relief have a minimal resolution of 508 dpi. The cartographic image is a precise, vector representation of an analogue map – created through the transformation of each element of a numerical map into a sign (a group of vector objects constituting the image in accordance with the pattern of the pre-arranged sign). In the organizational process of the creation of the hydrographic map we are dealing with the editor, the contractor and consultants.

The map is commissioned and edited by Chief Geodesist of the Country and the Voivodship Marshal. The contractor is understood as the team of geographers–hydrographers,

cartographers and geodesists cooperating with specialists in the fields of hydrology, water management and computer science.

Apart from the chief scientific consultant, who supervises the content of all sheets of the hydrographic map, its layout and the content of the commentary, there is a regional scientific consultant – responsible for the factual content of the map and commentary in the chosen region. The scientific consultant of the sheet is in turn responsible for the preparation of the given sheet of the map.

There is a rule that the updating of each sheet of the hydrographic map is conducted, depending on the needs, every 5 to 10 years.

By the end of 2006 the total of 554 sheets of the *Hydrographic Map* have been accomplished, covering 51% of the area of Poland. Recently the sheets have been done on the VMap L2 foundation, basing on new technical directives GIS–3.

*The Map of the Hydrographic Division of Poland* at the scale of 1: 50,000 is prepared by the Institute of Meteorology and Water Management under the auspices of the Ministry of the Environment and financed by the National Fund for Environmental Protection and Water Management.

The map presents:

- the uniform, continuous hydrographic database for the whole area of Poland in the 1992 coordinate system
- the set of vector informatics layers GIS (ArcInfo) with a reference database (full geometric and descriptive characteristics of the water network and river catchments)
- the basis for the creation and periodical updating of thematic layers in the range of water management, hydrography, geology, protection of nature, etc.
- the visualization and cartographic presentation of hydrographic data of varied thematic range, in the catchment system.

The sources for this map are the topographic maps (1: 50,000) in the 1942 coordinate system, diapositives of water network and relief maps, maps of the division into hydrographic units.

The informatics layers (ArcInfo coverage) comprise:

- marked streams, i.e. such for which catchments have been pointed out ( rivers, streams, canals, ditches, etc.)
- marked lakes (lakes, reservoirs, ponds)
- catchments (in the hierarchic system)
- unmarked streams, i. e. such that can, if necessary, be moved to a marked layer, after their catchment has been pointed out
- unmarked lakes.

The reference database comprises mainly:

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- marked streams sections, with the description of their character, type, kind, width, length, etc.
- watersheds with their category, length, course, type
- catchments – their perimeter, area, type (e.g. bifurcating, with no surface outflow)
- characteristic points on streams (e.g. water spring) and watersheds (e.g. water gates)
- lakes – their area and perimeter
- hydrographic identifiers of streams and catchments
- vocabulary index – names of catchments, streams, lakes.

*The Sozological Map of Poland* (1: 50,000) presents human influence on natural environment. Works on a serial *Sozological Map of Poland* began in 1990. In scientific and organizational respect it is related to the *Hydrographic Map of Poland* (1: 50,000), which is advantageous for the uniformity of both maps. *The Sozological Map* contains a lot of factual content from the range of hydrography and water management, such as water intakes and protection zones, areas threatened by river or storm flooding, water contamination.

The content concerning degradation of surface water comprises information about:

- sewage discharge (place of outflow, character)
- exceeding surface water contamination indices (physical, chemical, bacteriological)
- quality of surface water in gauging stations (cleanliness classes, exceeding cleanliness norms)
- contamination of coastal water (river water, industrial, municipal and agricultural sewage discharge, etc.).

The content referring to the change in water conditions concerns mainly the anthropogenic influence on the rivers and water reservoirs regime – comprising such information as:

- swollen surface water
- industrial water reservoirs
- fish-breeding ponds
- other artificial water reservoirs
- the loss of hydraulic links ( long-lasting lowering of underground water surface causing the loss of contact with river water, tightly built-up river beds)
- anthropogenic distortions of the hydrological regime of the stream
- stream beds artificially transformed.

The content concerning the degradation of underground water comprises such information as:

- grounds particularly susceptible to infiltration
- contaminated underground water (mainly on anthropogenic lands in non-seweraged settlements)
- direction of contamination transport in underground water (the direction stated or suspected)



- underground water surface artificially lowered
- depression sink (at present) – on the areas of water intake, mining exploitation, etc.
- renewability of underground water resources and their admissible management.

By the end of 2006 the total of 578 sheets of the *Sozological Map of Poland* have been accomplished, covering 53% of the area of Poland. Recently the sheets have been done on the VMap L2 foundation, basing on new technical directives GIS-4.

*The Hydrogeological Map of Poland* (1: 50,000) has been worked up by the State Institute of Geology in the years 1996 – 2004, commissioned by the Minister of the Environment. It is a serial map, accomplished in sheets, on the topographic foundation in the 1942 coordinate system, in the INTEGRAPH computer system. It has been created on the basis of the detailed *Geological Map of Poland* (1: 50,000). Altogether 1069 sheets of the *Hydrogeological Map* cover the whole area of the country.

This map is a cartographic projection of hydrogeological conditions, as well as these economical and sozological elements which are related to the threat to underground water and its renewal.

The content of the map comprises: the layout, quantitative characteristics, dynamics and quality of water, as well as the degree of the threat to this quality. The map contains the following information:

- hydrogeological regionalization
- watera – bearing characteristics
- hydrodynamics
- quality of underground water (main usable water – bearing level, water quality indices, contamination sources, river water purity classes)
- degree of threat to underground water
- representative water springs, bore – holes, dug wells

Explanatory text for each sheet comprises such data as:

- introduction
- localization
- climate, surface water
- hydrogeological conditions
- underground water quality
- threat to water and water protection.

The text contains hydrogeological cross – sections and complementary maps (depths of the occurrence of the main water–bearing level, as well as its thickness and conductivity).

The subject matter of hydrography and related to hydrography is also presented in various general maps, review maps or detailed maps: geological – environmental, geological – economical, and atlases.

For example, the *Geological – Economical Map* (1: 50,000), worked up since 1997, meets the requirements of GIS. Besides five thematic groups: minerals, mining and minerals processing, conditions of building substratum, protection of nature, landscape and monuments of culture, the map deals also with water and presents, among others, the chosen hydrogeological elements intrinsic for the protection of surface and underground water against irrational spatial management. For surface water the cleanliness class for river water is established. The borders of main reservoirs of underground water are designated, as well as the borders of areas of the degraded quality of underground water, borders of depression sinks and protection zones for spas and water intakes. For the sea–coastal zone a comprehensive legend has been introduced, comprising the issues concerning the dynamics of land and sea zones, as well as the hydrotechnical infrastructure. Each sheet of the map is accompanied by extensive explanatory text.

In the nineties, in the Institute for Land Reclamation and Grassland Farming a spatial information system was accomplished, concerning swamps and grasslands and destined for generating thematic maps and the creation of the *Atlas of the Swamps of Poland – natural and transformed.*, at the scale of 1: 300,000. The maps comprised in it are divided into sheets 1x1 geographical degree, in the 1942 coordinate system.

The factual content of the atlas consists of:

- protected areas
- outlines of swamps, considering: the occurrence of plant communities, type of swamps and the degree of anthropogenization, the area of swamps (below 10 ha, 10–50 ha, more than 50 ha).
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*The Atlas of Swamps* contains two sets of thematic maps at the scale of 1:300,000 comprising the area of the whole country with legends, sheet index and factual introduction.

*The Atlas of the Hydrographic Division of Poland* (based on the *Map of Hydrographic Division of Poland* 1: 50,000), published by the Institute of Meteorology and Water Management in 2005, comprises 112 sheets at the scale of 1: 200,000 and the numerical – descriptive part (the characteristics of the hydrographic division of Poland, water network, watersheds, etc). The river network presented comprises 770 thousand objects (14 thousand of them being marked rivers), more than 29 thousand elementary catchments divided by watersheds up to category IX, 11 thousand of lakes of the area exceeding 100 ha, etc.

## 5. CONCLUSION

The above presented review of spatial information systems and cartographic studies concerning water conditions proves that the issues discussed play a significant role in the implementation of sustainable development policy in Poland. Working up regional and local socio – economical and ecological policy has to be based on good diagnoses of natural environment resources, within which water holds, especially in Poland, a key position.

The range of fields in which hydrographic, hydrogeological and related to them information may be used is very wide and comprises, among others:

- spatial planning and management
- issuing decisions concerning localization of ventures troublesome for environment
- planning investments in the range of water management
- designing water intakes and protection zones
- drawing up the listing of underground and surface water constituting the source of water supply
- working up programmes for surface and underground water protection.

The contemporary spatial planning in Poland makes a wide use of the existing databases, information systems, cartographic documents, etc. concerning hydrography. This information is used in regional and local planning in the range of water management and protection [Koreleski 2005].

The deficit of water in Poland forces the economical approach to water management. In practice, unfortunately, this also means raising the price of water. For example, a pro-ecological tax reform in Germany in the 90s was aimed at introducing such system of fines and bonuses that would promote the increase in the efficiency of resources management, including water. However, obtaining energy from unconventional sources (e.g. hydroelectric power plants) should be exempt from taxes. Such approach to the issue of water in economy, gradually implemented also in Poland, serves the realization of the principles of sustainable development.

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## BIOGRAPHICAL NOTES

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