



## A STATE OF THE DOCUMENTING PROCESS OF THE ACCESSIBLE GROUNDWATER RESOURCES IN POLAND

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**Abstract.** The inventory of the state of the documenting process of available groundwater resources (as of 31.12.2006 – Herbich *et al.*, 2007) has revealed that available groundwater resources have been assessed for 42.9% of Poland’s area. For the remaining part of the country’s territory, perspective groundwater resources were determined (Herbich *et al.*, 2003) in order to make an assessment of all resources. The significance of perspective groundwater resources, assessed with the use of approximate methods, is tentative until the state of full assessment of available resources of the whole country is attained. Perspective and available resources are the basis for the assessment of the amount of groundwater resources accessible for the use in catchment areas and water regions.

**Key words:** groundwater, available resources, perspective resources, groundwater resources accessible for the use, groundwater bodies.

**Abstrakt.** Inwentaryzacja stanu udokumentowania zasobów dyspozycyjnych wód podziemnych wykazała, że według stanu na dzień 31.12.2006 r. (Herbich *et al.*, 2007) zasoby dyspozycyjne zostały ustalone dla obszarów o powierzchni stanowiącej 42.9% kraju. Na potrzeby dokonania oceny stanu zasobów wodnych kraju, dla obszarów nie objętych udokumentowaniem dyspozycyjnych zasobów wód podziemnych, zostały ustalone zasoby perspektywiczne wód podziemnych (Herbich *et al.*, 2003). Znaczenie oszacowanych, z zastosowaniem uproszczonych metod, zasobów perspektywicznych ma charakter tymczasowy – do osiągnięcia stanu pełnego udokumentowania zasobów dyspozycyjnych dla całego kraju. Zasoby perspektywiczne wraz z zasobami dyspozycyjnymi stanowią podstawę dla oceny ilości zasobów wód podziemnych dostępnych do zagospodarowania w skali obszarów dorzeczy i regionów wodnych.

**Słowa kluczowe:** wody podziemne, zasoby dyspozycyjne, zasoby perspektywiczne, dostępne do zagospodarowania zasoby wód podziemnych, jednolite części wód podziemnych.

### INTRODUCTION

According to the legal regulations in Poland (Rozporządzenie Ministra Środowiska, 2005; Słownik hydrogeologiczny, 2002), there are two types of groundwater resources accessible for the use. These are (1) admissible resources which amount is strictly connected with the intake – technical, economic and hydrogeological conditions of production, and with the water demand of the user, but under environmental protection regulations, and (2) available resources assessed as groundwater resources possible for the use within a given area under the determined environmental and hydrogeological conditions with no reference to the location of intakes and their technical as well as economic conditions. *The*

*Water Law* (2005), which is the implementation of the Water Framework Directive (2000) into domestic regulations, commit the Minister of the Environment and directors of regional water management authorities to making, among others, the assessment of groundwater quantities for the needs of development of water management planning in catchment areas and the determination of water use conditions in the water region.

The assessment of the groundwater quantity requires determination of the amount of groundwater resources, possible for the use, in catchment areas and water regions as well as in groundwater bodies (Herbich *et al.*, 2005).

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## AVAILABLE GROUNDWATER RESOURCES

According to *The Geological and Mining Law* from 1994, available groundwater resources are determined by the documenting procedure based on hydrogeological documentations. In accordance with current regulations (Rozporządzenie Ministra Środowiska, 2005) and the methodology used (Paczyński *et al.*, 1996), the assessment of available groundwater resources includes: hydrogeological conditions, groundwater system and quality of usable aquifers, anthropogenic and geogenic degradation risk, communication with surface waters, groundwater renewal rate and its variations over several-year periods, as well as the amount of groundwater flow indispensable to attain surface water quality goals (base flows) and to protect groundwater-dependent land ecosystems (groundwater heads). The mathematical modelling is the basic method used to determine the available resources.

The knowledge on the current state of the documenting process of available groundwater resources was derived from the inventory of archival hydrogeological documentations stored in the Central Geological Archives. The inventory was performed to create a report on *The determination of the perspective groundwater resources for the areas administered by the regional water authorities (final report)* (Herbich *et al.*, 2003). In early 2007, the knowledge on the groundwater resources was updated by taking account of documentations produced after 2003 and considered by the Commission on Hydrogeological Documentations by December 2006. During 1994–2006, a total of 67 hydrogeological documentations were produced to determine available groundwater resources.

The inventory of the state of the documenting process (as of 31.12.2006) has revealed that available groundwater resources have been assessed for 42.9% of Poland's area (Tables 1 and 2). Distribution of areas with documented available resources varies from region to region. The highest percentage of areas with documented available resources (>50%) is in the water regions of Lower Odra, Middle Vistula, Lower Vistula and Mała Wisła rivers, administered by regional water management authorities in Szczecin, Warszawa, Gdańsk and Gliwice, respectively (Table 1, Fig. 1).

In the southern part of the Middle Odra River basin, administered by the Regional Water Management Authority in Wrocław, the documenting procedure covered parts of the Obrzyca, Barycz, Widawa, Mała Panew, Nysa Łużycka, Bóbr, Kaczawa, Bystrzyca and Nysa Kłodzka River basins, best

explored in terms of hydrogeological conditions and accounting for 38.5% of the total area of the region.

In the Warta River Basin, administered by the Regional Water Management Authority in Poznań, available groundwater resources have been documented for the Upper Warta Basin downriver to the Liswarta junction, for part of the Warta Basin from the Ner junction downriver to the Proсна junction, and for the Warta River Basin near Poznań.

Within the Leszno Upland, situated at the boundary of the Warta and Middle Odra water regions, available resources of Tertiary groundwater have been documented. In the Warta region, available groundwater resources have been documented for 14% of the area.

In the Upper Odra region (RWMA in Gliwice), available resources have been documented for the Kłodnica River Basin covering 27% of the area.

In the Upper Vistula region (RWMA in Kraków), available resources have been documented for areas covering 26% of the region, and situated within the Soła, Wisłok and Middle San River basins, within the tributaries of the Vistula River of the northern part of the Carpathian Foredeep as well as within several small basins near Kielce.

In the Middle Vistula region (RWMA in Warsaw), encompassing over 36% of the country's area, the following river basins have been assessed for available groundwater resources: Wieprz, Bug, Pilica, Middle Radomka and Jeziorka rivers and the Mazurian Lake District. They account for approximately 28% of the water region. Outside the basin system, available resources have been documented for a Tertiary groundwater reservoir in the central part of the Mazowsze Basin.

Table 1

A state of documenting process of the available groundwater resources in water regions

Water region	Regional Water Management Boards head office	Area [km <sup>2</sup> ]	Area with documented available GW resources [km <sup>2</sup> ]	Percentage of documented available GW resources [%]
Mała Wisła and Upper Odra	Gliwice	3806	2202.0	57.9
		3693	1001.1	27.1
Upper Vistula	Kraków	43,608	11 298.9	25.9
Middle Vistula	Warszawa	112,305	61 928.0	55.1
Lower Vistula	Gdańsk	34,670	18 117.5	52.2
Middle Odra	Wrocław	38,808	14 987.0	38.5
Warta	Poznań	54,520	7 687.0	14.0
Lower Odra and Western Coastal Region	Szczecin	19,962	16 348.6	81.9

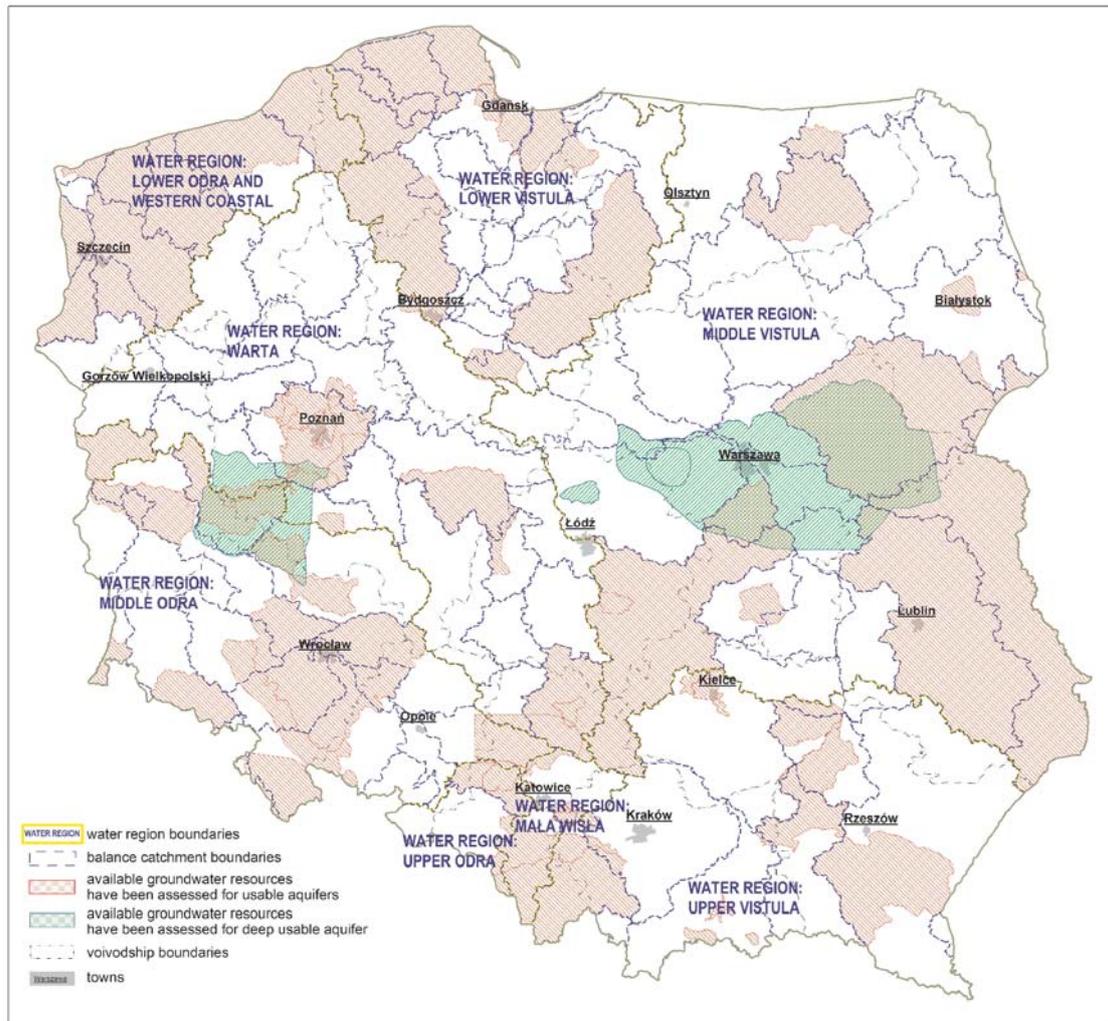


Fig. 1. A state of the documenting process of the available groundwater resources in Poland

## PERSPECTIVE GROUNDWATER RESOURCES

As the available groundwater resources of Poland have been assessed only in part, there is an urgent necessity to appropriately supplement our knowledge on the groundwater resources accessible for the use in the remaining regions of the country with accuracy which would allow for making an analysis of groundwater resources for 8 water regions administered by 7 regional water management authorities. For this purpose, perspective groundwater resources have been assessed (Herbich *et al.*, 2003) in areas which have not been covered by the documenting process of available groundwater resources. In 2004, they were positively approved by the Commission on Hydrogeological Documentations at the Ministry of the Environment.

Perspective groundwater resources are defined as those groundwater quantity available for the use in water regions and catchment areas, which are determined by approximate

methods taking into account the need to retain river base flows and preserve river valley water ecosystems. The assessment of the underground run-off to rivers which water level is measured on a long-term basis, is the principle method to determine the perspective groundwater resources (Herbich *et al.*, 2003; Herbich, 2005).

In areas of considerable concentration of large groundwater intakes and mine dewatering systems with extensive zones of their influence, perspective groundwater resources have been estimated based on a hydrogeological analogy method to regions of the water balance calculated by modelling methods.

The perspective groundwater resources, assessed with the use of approximate methods, are estimated tentatively until the state of full assessment of available resources of the whole country is attained.

## GROUNDWATER RESOURCES ACCESSIBLE FOR THE USE IN POLAND

Groundwater resources accessible for the use include perspective and available groundwater resources (Table 2, Fig. 1). The so-defined groundwater resources can be used to carry out an analysis of the quantity of groundwater resources in catchment areas and water regions, as well as to make a register of groundwaters intended for human consumption. These documents are being prepared to make a plan of water management in catchment areas and to determine water use conditions in the water region.

Perspective groundwater resources were used to make an assessment of the quantity of groundwater bodies (Herbich *et al.*, 2005), and to identify regional water deficit areas within individual voivodships. This task is being developed by the Polish Hydrogeological Survey (Działalność PSH ..., 2005, 2006, 2007).

In the Vistula River Basin, the total amount of available and perspective groundwater resources is 22.14 Mm<sup>3</sup>/day that is 8.08 km<sup>3</sup>/year. Considering the area of the Vistula River Basin which lies within the territory of Poland (194.4 km<sup>2</sup>, including the river basins of Danube, Dniester, Nemunas, Pregolya, Świeża and Jarft and those of the Eastern Coastal Region), the average groundwater resources accessible for the use (perspective and available), expressed per square km for the basin, is 114 m<sup>3</sup>/day × km<sup>2</sup> (1.32 l/sec × km<sup>2</sup> i.e. 42 mm/year). The underground run-off from the Vistula Basin is estimated at approximately 17.4 km<sup>3</sup>/year (Herbich *et al.*, 2003), that accounts for 52% of the average run-off from the Vistula Basin, determined for the period of 1951–1995. Thus, available and perspective resources make up about 47% of the underground run-off to rivers within the Vistula Basin.

In the Odra River basin the total amounts of the resources are 15.83 Mm<sup>3</sup>/day that is 5.78 km<sup>3</sup>/year. Considering the total basin area (116.9 km<sup>2</sup>), the average groundwater resources accessible for the use (perspective and available), expressed per square km for the basin, is 137 m<sup>3</sup>/day × km<sup>2</sup> (1.58 l/sec × km<sup>2</sup> i.e. 50 mm/year). Available groundwater resources account for 36.4% of the value. The underground run-off from the Odra River and the Western Coastal Region River basins is estimated at approximately 9.72 km<sup>3</sup>/year (Herbich *et al.*, 2003), that is 43.8% of the av-

erage run-off from the basins, determined for the period of 1951–1995. Thus, available and perspective resources make up about 60% of the underground run-off to rivers in the Odra River and the Western Coastal Region River basins.

Groundwater resources (perspective and available) accessible for the use, assessed for the whole country, amount to 37.97 Mm<sup>3</sup>/day, i.e. 13.8 km<sup>3</sup>/year (Herbich *et al.*, 2007). Statistically, it is about 1.0 m<sup>3</sup> of water per person a day. In 2004, the extraction of groundwater for municipal water supply systems in the country was 1 406 Mm<sup>3</sup>, average 3.91 Mm<sup>3</sup>/day, i.e. statistically 101 liters per person a day (GUS, 2005). It accounted for 67% of all groundwater used for municipal purposes (the amount of surface water supply to municipal supply systems was 696 Mm<sup>3</sup> in 2004). The water supply to the systems accounted for 80% of the total groundwater withdrawal (1 630 Mm<sup>3</sup>/day that is 4.46 km<sup>3</sup>/year) both for production purposes and to meet social needs (GUS, 2005).

On the country scale, the groundwater withdrawal recorded by the Central Statistical Office is just about 13% of groundwater resources available for economic use.

**Table 2**

**The groundwater resources accessible for the use in water regions  
(available and perspective) on the 31st of December 2006  
(according to Herbich *et al.*, 2007)**

Water region	Area [km <sup>2</sup> ]	Available GW resources [× 10 <sup>3</sup> m <sup>3</sup> /d]	Perspective GW resources [× 10 <sup>3</sup> m <sup>3</sup> /d]	The GW resources accessible for the use [× 10 <sup>3</sup> m <sup>3</sup> /d]
Mała Wisła	3 806	298.0	529.0	827.0
Upper Vistula	43,608	846.7	3 969.4	4 816.2
Middle Vistula	112,305	5 378.2	7 142.7	12 520.9
Lower Vistula	34,670	2 046.9	1 930.0	3 976.9
Upper Odra	3 693	126.9	420.0	546.9
Middle Odra	38,808	2 037.3	2 856.0	4 893.0
Warta	54,520	1 328.0	5 830.0	7 158.0
Lower Odra and Western Coastal Region	19,96	2 782.6	447.1	3 229.7
Vistula Basin	194,389	8 569.9	13 571.1	22 141.0
Odra Basin	116,983	6 274.5	9 553.0	15 827.5
<b>The country as a whole</b>	<b>311,372</b>	<b>14 844.4*</b>	<b>23 124.2</b>	<b>37 968.6</b>

\* – available GW resources assessed for the area of 133 570.1 km<sup>2</sup> (42.9% of the Poland's territory)

## SUMMARY

The amount of groundwater resources accessible for the use is the total of available resources, documented in compliance with procedures defined by *The Geological and Mining Law*, and perspective resources assessed by approximate meth-

ods. The total amount of groundwater resources accessible for the use in Poland is approximately 37.97 Mm<sup>3</sup>/day (13.8 km<sup>3</sup>/year). The groundwater resources accessible for the use were the basis for the analysis of groundwater resources in

catchment areas, water regions, as well as for the assessment of the quantity of groundwater bodies.

Available groundwater resources have been assessed so far for 42.9% of Poland's area. The amount of the documented re-

sources is 14.84 Mm<sup>3</sup>/day. The Lower Odra River and Western Coastal areas are the best documented regions (81.9% of the region's area), whereas the Warta water region is most poorly documented (14% of the region's area).

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