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TRANSBOUNDARY GROUNDWATER BODIES AS A TASK OF THE POLISH STATE HYDROGEOLOGICAL SURVEY

Andrzej SADURSKI[1]

Abstract. The EU Framework Water Directive is a general legal act oriented towards the sustainable utilization, protection and improvement of the water resources state. Groundwater bodies delineated by the Polish State Hydrogeological Survey (PSHS) have to be monitored and the results of monitoring are aimed at the action plans of the water management. Some groundwater bodies are situated along the Polish boundary zones and these have to be controlled by both sides: PSHS and specialising services of the neighbouring countries. The detailed procedures of monitoring, elaboration of the results and trend analyses have to be carried out by international team within the frame of EU.

Key words: Water Framework Directive, groundwater monitoring, groundwater protection, groundwater.

Abstrakt. Ramowa Dyrektywa Wodna Unii Europejskiej jest podstawowym aktem prawnym ukierunkowanym na zrównoważone wykorzystanie i ochronę zasobów wodnych oraz poprawę ich stanu. Zbiorniki wód podziemnych zidentyfikowane przez polską Państwową Służbę Hydrogeologiczną muszą być monitorowane, a wyniki tego monitoringu mają służyć do tworzenia planów zarządzania zasobami wodnymi. Zbiorniki wód podziemnych usytuowane w strefach granicznych muszą być nadzorowane przez PSH oraz wyspecjalizowane służby krajów sąsiadujących. Szczegółowe procedury monitoringu, opracowywanie wyników i analizy trendów muszą być prowadzone przez zespoły międzynarodowe zgodnie z zasadami Unii Europejskiej.

Słowa kluczowe: Ramowa Dyrektywa Wodna, monitoring wód podziemnych, ochrona wód podziemnych, wody podziemne.

INTRODUCTION

Poland's accession to the European Union has caused a necessity of implementation of the EU directives regarding water management. In the Water Framework Directive (2000/60/EC), an important role in water protection and management and in determination of the groundwater influence on groundwater-dependent ecosystems has been committed to water monitoring, including also groundwater monitoring.

The Water Act of the 27 April, 2001 established by the Polish Parliament, laid out the water management regulations in accordance with the balanced development concept adopted in the State's pro-ecological policy which accounts for assessment, protection and exploitation of water resources. The new legal regulations aim at "providing population with the required water quantity and quality, maintaining and improving the state of aquatic ecosystems and those depending upon water, protecting against floods and droughts, meeting needs related to tourism, sports and recreation, as well as developing conditions for energetic, transport and fishing exploitation of waters". These objectives are similar to the rules defined in the Water Framework Directive. The process of implementation of the regulations is carried out in accordance with the schedule described in the Water Framework Directive.

The State Hydrogeological Survey, establish by the Water Act, has been started to run by the Polish Geological Institute in January 2002. The State Hydrogeological Survey carries out all the tasks related to the water resources evaluation, preparation of the annual balances, and protection of groundwater in order to maintain its rational exploitation for public and eco-

[1] Polish Geological Institute, Warsaw, Rakowiecka 4, 00-975 Warszawa, Poland; e-mail: andrzej.sadurski@pgi.gov.pl

nomic purposes. Tasks of the Polish State Hydrogeological Survey include:

- performing hydrogeological measurements and observations;
- collecting, processing, archiving, and making available the information, particularly on the resources, state and quality of groundwater;
- conducting current analyses and assessments of hydrogeological situation;
- compiling and forwarding to the appropriate administration authorities all the information on the forecasts of the changes in the resources and in their quality and on the groundwater threats;
- compiling and forwarding to the public administration warnings on dangerous phenomena occurring in supply zones and groundwater captures.

The Polish State Hydrogeological Survey maintains a permanent observation network of groundwater, and manages teams which conduct hydrogeological assessments and forecasts (Fig. 1). The groundwater observation network comprises of:

- hydrogeological stations,
- points of groundwater state observation,
- points of groundwater quality monitoring,
- observation piezometers,
- built-up wells.

The Polish State Hydrogeological Survey supervises activities of the national monitoring network of groundwater quality and the regional monitoring networks (Hordejuk, 1996; Kazimierski, Sadurski eds., 1999; Kazimierski ed., 2004). It enables planning and subsequent organization of the groundwater monitoring system and other related necessary operations. One of the first steps was identification and preliminary recognition of vulnerable and protected transboundary groundwater bodies. Depending on the state and position of the groundwater bodies in the natural environment, it is possible to change the range of monitoring.

A schedule of the monitoring implementation was elaborated in accordance with the WFD (Guidance 2.7, 2002) in years 2002–2005. Preliminary identification and characterisation of groundwater bodies was completed at the end of 2004. Recognition of demands for information on the groundwater bodies, required for development of monitoring strategy based on groundwater characterisation, is to continue till the end of 2005. Planning and organizing new monitoring points, and also implementing a strategy of the quantitative and chemical (diagnostic and operational) monitoring systems as an operational one, will be completed in 2006.

Assessment of monitoring results, interpretation and reporting on groundwater quality, and securing the groundwater bodies good quality, is planned to be finished at the end of 2008.

Fig. 1. Hydrogeological station of Polish Geological Institute — the observation network of groundwater body

GROUNDWATER RESOURCES IN POLAND

Groundwater resources are defined by quantities of groundwater that can be used for social, living, farming or industrial needs, accounting for the protection of natural environment in their capture place (exploitation resources of groundwater intakes) or in a specific area, e.g. the water catchment area, without indicating the location of the groundwater exploitation. Sustainable development and pro-ecological rules of water management demand that some part of the water resources should remain available to animated nature, both plants and animals. How difficult it is to assess, could be exemplified by differences in opinions on definitions of the untouchable (biological) course of rivers.

A part of groundwater resources which flows annually to rivers is for the whole area of Poland estimated at 15.55 km^3. It is restored by precipitation infiltrating to the ground. The mean annual precipitation is about 600 mm/yr, and 25% of it recharges the water bearing strata. The fresh groundwater is circulating below the surface to the average depth of 200 m and is an inconspicuous component of the hydrological cycle.

Water resources in Poland reveal significant changeability in time. During wet years, the rainfalls are twice as big as during dry years, and one can observe fluctuations in the groundwater level and in the amount of precipitation in a several-year cycle.

Fresh water resources occurring to the average depth of 200 m, exceed in Poland 5.000 km^2, and in 75–80% they are still not polluted with substances discharged by people into the environment. The total volume of waters gathered in surface bodies in Poland amounts to approximately 34 km^3. However, nearly 50% of potable water supply comes from groundwater resources. In many places there is no alternative source of wa-

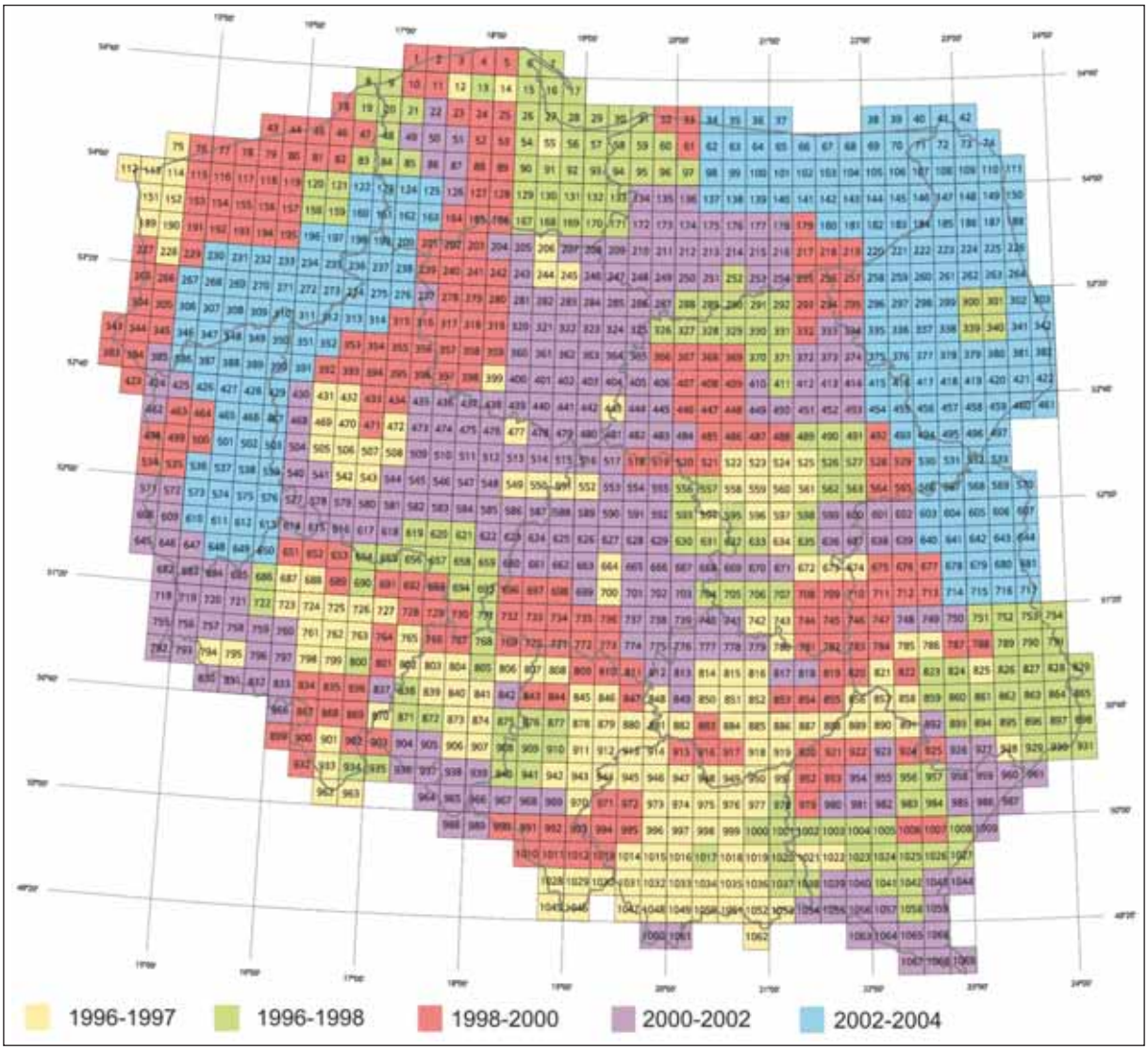

Fig. 2. Sheets of the Hydrogeological Map of Poland, 1:50,000 distribution (according to Herbich, 2005)

ter intake apart from those from the aquifers. Taking into consideration valorisation of water resources as potable water sources, groundwaters significantly dominate over surface waters resources, and declines of their level means degradation of many ecosystems depending on groundwater supply. Hence, groundwater resources still constitute a large reserve of potable waters in Poland. The recognitions of groundwater resources is made and presented on the GIS/Intergraph Hydrogeological Map of Poland shown on Figure 2 (Herbich, 2005).

From the economic point of view, groundwaters are valuable as they do not usually require advanced and expensive treatment. Over the years, they have stable temperature and chemical composition. If they occur under a series of deposits of poor permeability, they are well protected against pollution from the surface of the terrain.

Structural economic changes in Poland and production restraints resulted in curbing water supply for industry and farming. Therefore, areas previously showing water deficit, presently reveal its excess which causes difficulties in functioning of technical infrastructure. Groundwater resources are not so prone to pollution, yet should it occur, they are difficult to get purified. This can be confirmed by the results of the undertaken remediation, for instance in the areas contaminated by industrial plants, in the neighbourhood of fuel tanks and communal waste dumps. Despite huge financial funds, ecological effectiveness of these measures is relatively small and the time needed to eliminate pollutions exceeds a man's life span.

During the floods, there are mass surface movements — landslides in the areas of river valleys slopes. Their occurrence correlates in time with floods. Therefore, monitoring of groundwater appears indispensable as the warning system.

The mentioned tasks, are important for the transboundary zone also and are undertaken by the Polish State Hydrogeological Survey.

GROUNDWATER BODIES IN POLAND

Groundwater bodies, according to the WFD, can be the hydrogeological units and also units area of groundwater resources. Therefore, the hydrogeological units are also objects for monitoring. They enable water exploitation in the amounts of 100 m^3/day for water supply. Groundwater bodies influence also land ecosystems and the surface waters state. It means that monitoring in Poland should cover all groundwater bodies. 160 groundwater bodies have been identified in the territory of Poland as a result of the hydrogeological investigations carried out by the Polish State Hydrogeological Survey (Nowicki *et al*., 2005).

The main criteria for their identification were following: water dynamics, facies development of the water-bearing strata, reaction to external factors, and the size of anthropogenic influence. In addition, an organizational criterion has been established in order to secure joint operations in monitoring and investigations on the balance between groundwater and surface waters.

A conceptual model of the groundwater bodies system takes into consideration the following features: rainfalls, geological structures, overburden of aquifers, hydraulic properties of the geological strata, associated surface ecosystems, natural characteristics of groundwater bodies, water intakes, artificial recharge and its consequences, point and dispersed pollution sources, information on abstraction pressures, consequences of errors in conceptual model and environmental factors requirements, monitoring data, understanding of groundwater flow system and its natural variability, sensibility of the aquifers to dewatering, vulnerability to the salt water ascension, and sea water encroachment along the shore line.

Borders of Poland situated along the big rivers are the natural borders of groundwater bodies. This situation prevails on the western site (border with Germany) and also on the south-eastern site (border with Ukraine and partly with Belarus). Southern border with Czech and Slovak Republics runs along the high mountains following the water divide. This is a European water divide between the Baltic, Black and North seas.

A map given on Figure 3, which illustrates the distribution of aggregated groundwater bodies (GWB), comprises:

- groundwater bodies which are threatened by not being able to comply with the requirements of the WFD, i.e. which are now overexploited (mainly due to mine dewatering) or of degraded quality;
- groundwater bodies which boundaries requirements will be lowered; in case of an occurrence of industrial objects exerting strong abstraction pressures, but which cannot be abandoned or limited for economic reasons;
- groundwater bodies located in border areas (cross-border ones will be delineated later in co-operation with neighbours);
- groundwater bodies protected by law (nature reserves, recharge areas, protected catchment areas).

The identified aggregated groundwater bodies are represented by complex, multi-level groundwater systems. During the next stages of the WFD implementation programme, it is planned to identify separate groundwater bodies of main and deep usable aquifers. Aquifers that show the highest dynamics and those which are anthropopressure-sensitive (vulnerable), have the highest priority for monitoring. They are represented by shallow or unconfined aquifers with usable groundwater of high dynamics, and by main usable aquifers (due to abstraction pressures caused by water extraction). Water-rich Quaternary aquifers are dominant in Poland. Control of groundwater bodies must also cover deeper confined aquifers isolated from the ground surface, if they are designated for or can serve as water supply (aquifers of confirmed disposable groundwater resources or delineated groundwater resources of drainage basins).

Fig. 3. Distribution of aggregated groundwater bodies in Poland (according to Nowicki *et al.*, 2005)

GROUNDWATER MONITORING

Identification and quantification of possible changes in the aquatic environment, including groundwater and ecosystems depending on the groundwater, will be necessary in order to assess the influence the undertakings will have upon the environment. These problems are particularly noticeable in underground and hydrotechnical constructions, during exploitation of mines, in linear constructions of transfer and/or communication investments (motorways, railway lines, pipelines) as well as at the stage of designing and environmental inspections of large industrial plants. In recent years, considerable attention has been given to post-farming pollutions which should be monitored in accordance with the EU Nitrogen Directive (Fig. 4). The Polish State Hydrogeological Survey should deliver the output data for the above assessment, recognition of the environmental state, control and also forecasts of these changes. According to the Water Framework Directive, monitoring should be provided for groundwater bodies. Its work will have an impact upon the effectiveness of the performed actions at both national and regional scales.

Neither WFD nor methodological handbooks (Guidance 2.7, 2002; Arnold ed., 1999) provide detailed regulations concerning the manner and range of monitoring. Development of the detailed programmes was left to the individual EU members, allowing to take into account local specific hydrogeological conditions and organizational and methodological approach applied in monitoring. However, it was noted that the accepted monitoring programme should be realistic, i.e. should be adequate to financial and organizational possibilities of the implementing institution.

In Poland, it is developed in the following way. Monitoring, consistent with the requirements of the WFD, covers investigations of the groundwater state defined as water quantity and chemistry. The monitoring process is run within a groundwater body separately for each of these two parameters, based

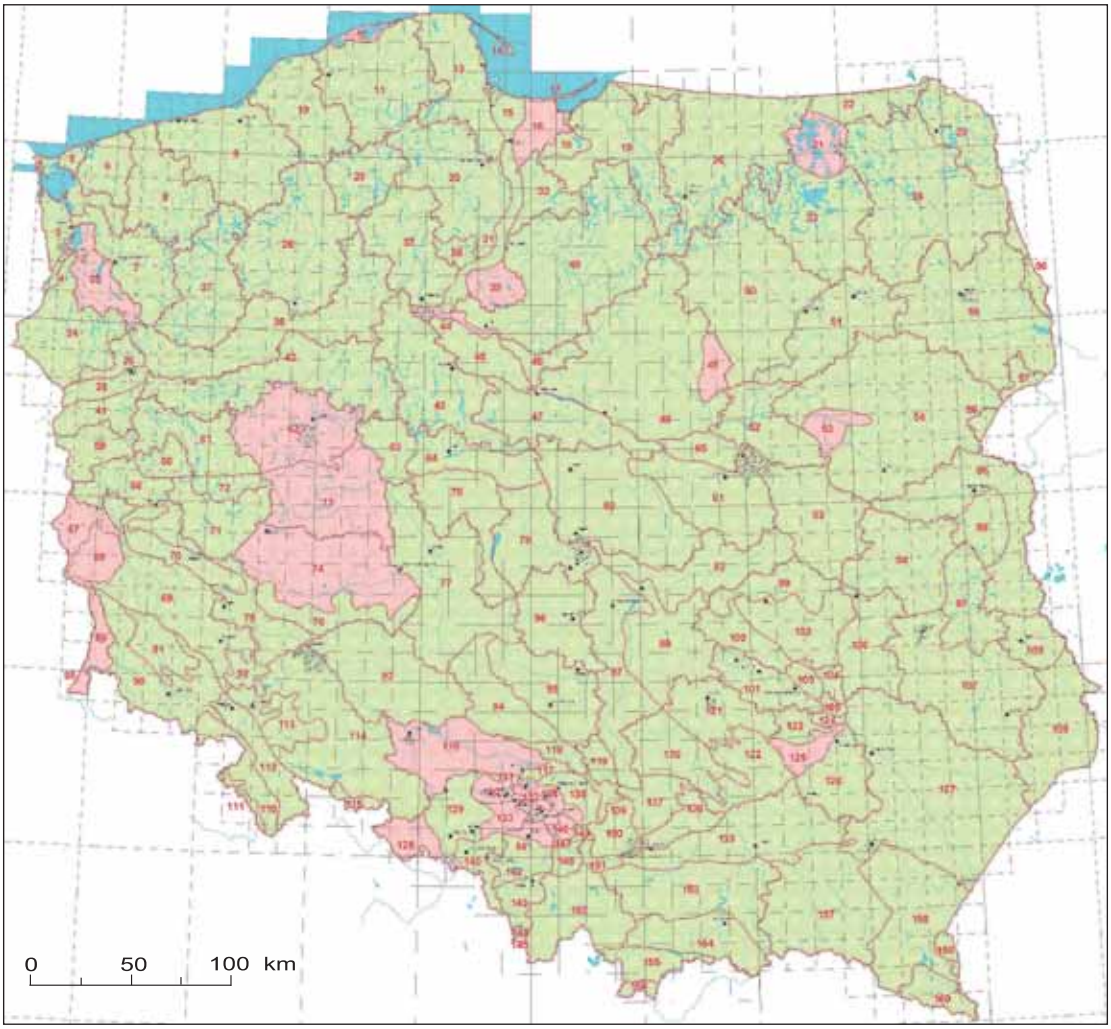

Fig. 4. The condition of groundwater bodies in Poland (according to Nowicki *et al.*, 2005)
Poor GWB condition is marked by red colour; good GWB condition — by green colour

on different sets of indicators. However, most of water samples are collected from the same observation wells or springs.

According to WFD and a Polish legal act – the Water Law – groundwater monitoring for investigations of water chemistry should be performed through diagnostic, operational and investigative monitoring (Guidance..., 2002).

Quantity of water resources of a groundwater body reflects the extent to which it is exposed to direct and indirect water extraction, and associated lowering of water level. It is assumed that the assessment is based on the following monitored parameters:

— amount of available groundwater resources understood as the amount of disposable resources, and if these are lacking, as the amount of groundwater resources of drainage basin, expressed in m^3/day,
— amount of long-term measured (average) water intake from groundwater catchments, in m^3/day,
— groundwater level in metres a.s.l. or water spring discharge in l/s,
— groundwater flow direction and flow rate (can be determined based on data from the Hydrogeological Map of Poland, 1:50,000).

Measurements of groundwater level or spring discharge are made once a week, but in transboundary observation points situated on the lowlands, only once a month. The measurement network of groundwater level will finally include about 1,500 observation points (wells and springs), 900 of which will cover measurements of shallow unconfined groundwater.

Operational monitoring provides data necessary to achieve the required confidence level in the classification of poor or good quality groundwater bodies at risk, or to detect significant increasing trends in pollution contents (Fig. 4). This kind of monitoring is conducted in transboundary zone also, and is oriented towards identification of the chemical state of all groundwater bodies or groups of groundwater bodies defined as being at risk, and towards identification of the presence of any long-term increasing trends in pollution contents caused by human activity.

INTERPRETATION OF THE RESULTS

Interpretation of the results relies on data processed to obtain information on the water environment state. The information is stored and processed with the use of a computer database developed by the Oracle system. The complete database contains all monitoring data which characterise the hydrogeological system, exerted abstraction pressures and investigative devices with their specifications. The database ensures the possibility of processing of all data. As a result of the interpretation, we obtain tabular, cartographic or chart information on the quantity and chemical composition of waters. Information on trends in contents changes of the major physical and chemical indicators is helpful in the assessment of groundwater bodies. A distinct increasing trend in the mentioned contents can be a reason for regarding the chemical state of the groundwater body as being at risk or poor. A chemical type and background should also be identified for groundwater.

The monitoring results are the basis for reports and assessments of the state of groundwater and groundwater bodies. A report contains a description of monitoring cycles or stages. It also includes information on the range of monitoring and its results. The monitoring results can be compiled in the repost as raw source data, i.e. prior to the final verification presented in tables, or recorded in a digital form. The report must include information on all difficulties encountered during the monitoring process and on all the deviations from the standard procedures of measuring and sampling. The assessment of the state covers the results of monitoring investigations in an integrated form, showing the state of the environment and its changes. It also includes recommendations concerning environmental protection.

CONCLUSIONS

Transboundary groundwater bodies are under control of monitoring system developed on the basis of observation network of the Polish Geological Institute. The groundwater monitoring in Poland started over 30 years ago. This system is under reconstruction and enlargement during the last years. The implementation of the Water Framework Directive into the legal system of Poland resulted in some changes in the procedures of the former groundwater monitoring. Former systems have been replaced by the GWB system focusing on the control of the quantitative and qualitative state of groundwater. By 2012, it is necessary to double the number of groundwater observation points in Poland and to organize observation points in border areas and in areas of groundwater threatened by pollution derived from the land surface. Along the boundary zone, the groundwater observation should be led by combined Polish and the neighbour countries teams.

The currently implemented new directive "groundwater vs. pollution" will include procedures of sampling, and physical and chemical analyses of shallow groundwater. It will also define the manner of data processing and storage in databases.

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