Guidelines on groundwater for the WFD Slovakia

Guidelines for the implementation of the groundwater aspects of the water framework directive in Slovakia

EVD

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Final Report

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1 INTRODUCTION

The project aims to assist the Slovak Republic in the implementation of the Water Framework Directive (WFD), Article 4 and both Annexes II and V. The general purpose of the WFD is to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater. Article 4 indicates that the member states have to take some actions when implementing programmes or measures specified in the River Basin Management Plans. The WFD provides a timeframe of nine years for the implementation by the Member States.

Main results of the project are:

1. the staff of the SHMU is able to design and implement initial delineation of groundwater bodies in Slovakia according to the requirements of the WFD, 2000/60/EC;
2. unified system of groundwater bodies characterisation designed and established in compliance with Annex II, Article 2.1 and 2.2 of the WFD;
3. master plan for a unified system of groundwater evaluation in accordance with the Annex V, Article 2, of the WFD, 2000/60/EC.

Content of this report
In the guidelines of the project the results 1. and 2. are documented. In the chapters the methodology used is described. The results of the applied methodology are all included in the annexes to this report. In chapter 2 the institutional settings of the authorities dealing with water are described briefly. In the chapter 3 we describe the methodology for the delineation and characterization of the groundwater bodies. In the next chapter 4 the methodology for the risk assessment of these bodies is covered. In chapter 5 deals with the further characterization of the groundwater bodies. This report finishes with some recommendations on monitoring.

2 INSTITUTIONAL SETTINGS

At present different organizations are responsible for parts of the water management in Slovakia. In the annex A an exhaustive description of their tasks and responsibilities is given. Hereunder a short summary of the organizations is presented;

National organisations:
- Ministry of the Environment (Water Division)
  Policy development on national level;
- Ministry of Health (MoH);
- Slovak Environmental Agency (SEA).

National research institutes
- Slovak Hydro-Meteorological Institute (SHMI)
  Research institute responsible for national monitoring network for water quality and quantity;
- Water Research Institute (WRI);
- Geological Survey (GS).

Regional and local offices
- River Basin Authorities (RBA) of the Slovak Water Management Enterprise (SWE)
  The 4 branch offices and the underlying local offices are responsible for the administration, maintenance and operation of water courses, water management works, drainage and irrigation equipments. Taxes on wastewater and groundwater abstractions are collected by the RBA's. Only the taxes on wastewater are used for their regional tasks. The taxes on groundwater flow to the state budget.
- District Environmental Offices
  Responsible for licensing, control and supervising of use and pollution of waters and abstraction of groundwater. The district office is also responsible for indicating groundwater protection areas.
- Regional Environmental Offices
  Same responsibilities as district offices, but only are active in case of international waters or transboundary waters, or if water structure covers or influences territory of two or more districts. Regional office also seems to be responsible for control of groundwater quality in groundwater protection zones.

- Water Inspection Centres of the Slovak Inspection of Environment (SIE)
  Located in 5 towns (Bratislava, Nitra, Zilina, Banska Bystrica, Kosice). They exert the supervision in extent and under conditions given by relevant acts and by the Ministry of Environment. The Inspection also imposes penalties for law infringement.
- Waterworks and Sewerage Companies (WSaS)
  In total 5 state owned companies responsible for water supply and waste water treatment. In some towns and villages this task is also performed by the municipality.

3 DELINEATION OF GROUNDWATER BODIES AND INITIAL CHARACTERISATION

3.1 Three-layers approach in groundwater bodies delineation (Slovakia)

In Slovakia it was decided to build a stratified structure of groundwater bodies of three different layers. As the country itself has a relatively high degree of geothermal potential, the deepest aquifers and the lowermost "groundwater body layer" should be that of geothermal waters. The division of geothermal structures in Slovakia (Franko et al. (1995), Fendek & Franko (2000) and Fendek et al. (2002)) was used to create the geothermal groundwater bodies. Together, 26 groundwater bodies were delineated in this layer, counting both intergranular (porous) aquifers of Neogene sediments and fissure-karst aquifers mostly of Mesozoic carbonate structures. An overview of the geothermal bodies is included in annex B.

The upper two layers of groundwater bodies differ from the geothermal one since they contain fresh water and both are delineated by combining hydrogeological rayons, sub-rayons and partial rayons (see 3.2). The intermediate layer of groundwater bodies is of Pre-Quaternary origin and is mostly recharged by precipitation water and drained by springs directed into surface streams, or directly by Quaternary sediments. Within the Pre-Quaternary groundwater bodies the major differences is the rock type with differences in permeability. We recognize 5 basic types:

- Fissure groundwater bodies of various rock masses from Crystalline to Palaeogene;
- Intergranular groundwater bodies of Neogene fillings of basins and intramontaneous depressions;
- Fissure and karst-fissure groundwater bodies of the Inner Carpathians;
- Dominant karst-fissure groundwater bodies of the Inner Carpathians;
- Fissure and intergranular groundwater bodies of the Neogene volcanoes.

3.2 Methodology for delineation

According the Common Implementation Strategy of the Water Framework Directive (2000/60/EC) a "water body" should be a coherent sub-unit in the river basin (district) to which the environmental objectives of the directive must apply. So far, the main purpose of delineating "water bodies" and respective "groundwater bodies" in each Member State is to enable their accurate description and comparison to environmental objectives. A "groundwater body" must be within an aquifer or aquifers.

Article 7 of the Water Framework Directive (2000/60/EC) requires the identification of all groundwater bodies used, or intended to be used, for the abstraction of more than 10 m^3 of drinking water a day as an average. Practically all geological units in Slovakia are able of yielding more than this quantity and thus all the territory of Slovakia should be involved in the process of delineation of groundwater bodies.

On the basis of the Horizontal guidance document the following methodology for the delineation of groundwater bodies was used (see also figure 3.1):

1. Hydrogeological rayons were identified.
   In Slovakia 141 rayons exist which are hydrogeological units which have been distinguished in the past to estimate the available amounts for abstractions. They therefore are the basis for the current licensing system for groundwater abstractions.
2. The country has been characterized in 4 different rock types:
   a. Quaternary unconsolidated rocks

b. pre-Quaternary- Karst-Fissured rocks
c. pre-Quaternary- Hard-Rocks
d. pre-Quaternary- Sedimentary basins

3. Layers 1 and 2 were combined, which resulted in a map with 392 rayons and sub rayons.
4. By combining sub-rayons with similar hydrogeological properties, the first map with groundwater bodies was produced.
5. Because the watersheds coincide with the administrative units of the 4 River Basin Authorities, it was decided to split groundwater bodies that cross an administrative border
6. A distinction was made between Pre-Quaternary groundwater bodies and overlying Quaternary groundwater bodies.

A third layer of Geothermal groundwater bodies was also produced from existing hydrogeological data. The above mentioned methodology was not used to distinguish these bodies.
A more detailed description of the used methodology and the intermediate results is presented in Annex B.

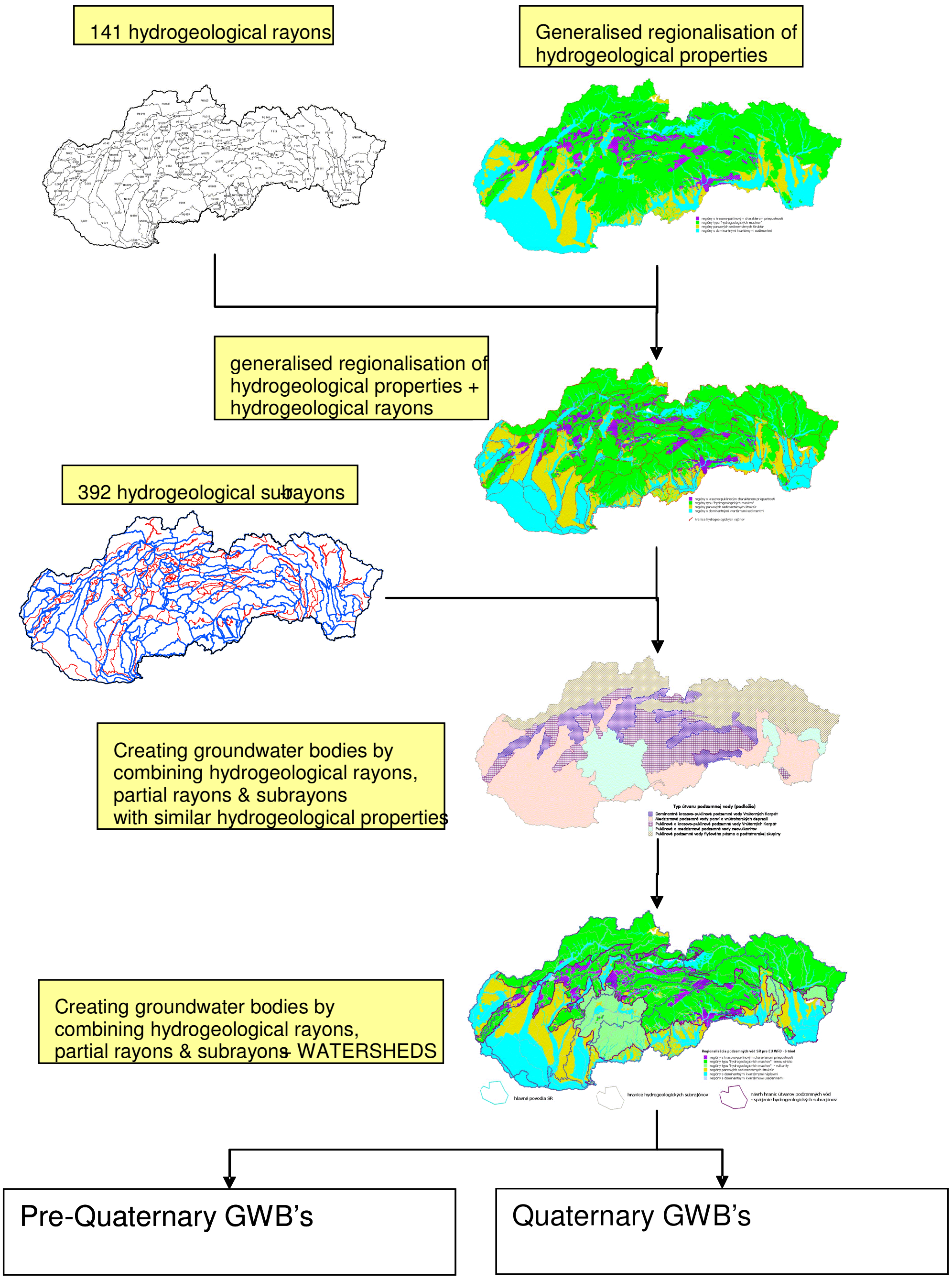

Figure 3.1 Methodlogy for initial delineation

4 GROUNDWATER BODIES AT RISK

4.1 Methodology for quantity pressures

An assessment of the quantitative status of groundwater bodies according the EU WFD can be carried out with different approaches. Generally, emphasis is given to the evaluation of groundwater table level changes within the time, possibly influenced by abstraction or other human activities. On the other hand, groundwater table levels can track artificial influence mostly in the lowland ecosystems, while more complex ground surface and geological environment can show different behaviour.

Human activities in mountainous regions can impact on spring discharges or stream base flow and runoff changes. From this point of view, Slovakia adopts a methodology of quantitative status assessment using existing information on potential groundwater resources and abstraction rates or the existing review of groundwater level time series. Generally, two mainstream approaches can be seen on the field of EU WFD implementation in quantitative groundwater status assessments:

1. analyses (mostly trend analyses) of monitored groundwater table levels within groundwater bodies and assessment of potential decrease trends;
2. complex setting of the ratio of acceptable abstraction load of the renewable groundwater resources within groundwater bodies.

Evaluation of groundwater quantitative status according point (1) should be based on monitoring data, gathered for the whole groundwater body. Short time series (1 – 3 years) should be compared with the long observation periods (10 – 30 years) and the trends of groundwater table levels should be calculated. In the case trend evaluation does not show any important decrease trend and in the same time there is no documented influence on the dependent ecosystems (including these, which are the parts of surface waters), then we can declare the good quantitative status of the respective groundwater body.

Estimation of exploitable amounts
Available groundwater amounts" in Slovakia represent the maximal amounts of groundwater, which can be used in certain natural settings of the area, respecting the ecological restrictions (needs of water-related ecosystems). Exploitable groundwater amounts were calculated according to hydrogeological investigations for 141 hydrogeological rayons (see annex F), but also for individual localities important from the water supply point of view. The Commission on Groundwater Resources and Reserves (KKZZ), now part of the Ministry of Environment, is responsible for evidence and approval of calculations of groundwater amounts. The Ministry of Environment classifies exploitable amounts of groundwater into 3 categories - A, B and C, depending on the accuracy of the estimation. More details on this estimation can be found in Annex C.

Groundwater abstraction data represent the results of data gathering by the Slovak Hydrometeorological Institute (SHMU). Institutions abstracting groundwater send the average monthly records on abstraction annually to the SHMU, if these abstractions exceed 1250 m3 per month, or 15000 m3 per year, or if artesian groundwater is exploited. The Groundwater Chapter of the report State Water Management Balance of Slovak Republic is updated and published annually. Contemporary balancing of exploitable amounts and real abstraction data is based on comparison of both values within the whole hydrogeological rayon. The balance status "Bs" is the reciprocal value of exploitation ratio and was given as the ratio of exploitable amounts and abstraction and subsequently classified into 5 categories:

Table 4.1 Classes of balance status

	balance status:				**exploitation ratio**
1.	good	3.33	< Bs		< 30%
2.	satisfactory	1.43	< Bs ≤	3.33	30 - 70%
3.	stressed	1.18	< Bs ≤	1.43	70 - 85%
4.	critical	1.00	< Bs ≤	1.18	85 – 100%
5.	emergency		Bs ≤	1.00	> 100%

According to the 2003 report of State Water Management Balance of Slovak Republic, part: Groundwater (status 31. 12. 2002), renewable natural resources of groundwater on the territory of Slovak Republic represent 146.7 m3/s in average. The current state of exploitable groundwater amounts, documented in 2002, counts nearly 51.9 % of the natural resources. The total of exploitable groundwater amounts thus counts 76.1093 m3/s. These amounts are subdivided into categories classified by the Commission on Groundwater Resources and Reserves (A, B and C, together 41.52856 m3/s) and those, estimated by SHMU (degrees I, II, III and estimate, together 34.58074 m3/s):

Table 4.2 Exploitable amounts of groundwater, subdivided according estimation classes (see also annex C for an explanation)

category A	826.00	$l.s^{-1}$
category B	1 938.30	$l.s^{-1}$
category C	639.71	$l.s^{-1}$
category C1	26 156.37	$l.s^{-1}$
category C2	11 968.18	$l.s^{-1}$
Σ:	**41 528.56**	$\mathbf{l.s^{-1}}$

degree I	10 781.14	$l.s^{-1}$
degree I	15 300.49	$l.s^{-1}$
degree I	8 013.11	$l.s^{-1}$
estimate	486.00	$l.s^{-1}$
Σ:	**34 580.74**	$\mathbf{l.s^{-1}}$

Estimation of groundwater abstraction

Groundwater abstraction is dependent not only on real and potential natural settings, but strongly depends also on economical criteria, mostly on water pricing changes, but also on overall economic growth. In 2002, total average abstraction of 1.3 million m3/s was reported by groundwater users. The main part of this amount (1 million m3/s, i.e. 78.4 %) was used as a drinking water supply through pipeline systems. Thus, in 2002 the total abstraction of groundwater reached only 17.1 % of total documented exploitable groundwater amounts. These figures document only an overall superficial glance at the whole reality, as such ration change from region to region (see also annex D).

Estimation of groundwater bodies at risk

Evaluation of groundwater quantitative status according to the point (2) is based on the assumption, that groundwater overexploitation over the threshold value given by the renewable groundwater resources (in the case of Slovakia defined as "natural groundwater resources" based on the terminology of Regulation No. 141 / 2000 Z.z. explaining the Law 313 / 1999 Z.z.) inevitably should lead after a certain period to the decrease of groundwater levels or decrease of the discharges of natural springs. Taking into account this approach, certain degree of preventive measures can be undertaken before the decrease can appear. The principal question there is the definition of the "available groundwater amounts" – whether they count for all renewable groundwater resources ("natural groundwater resources") or only represent a part, reduced by ecological needs and technical possibilities of exploitation.

Annually published report of the State Water Management Balance of Slovak Republic, part: Groundwater, edited by Slovak Hydrometeorological Institute should stand as an appropriate base for water quantity evaluation within groundwater bodies. The basic analyses of evaluating quantitative state should be divided into 5 autonomous steps:

1. assessment of exploitable groundwater amounts and its categorization;
2. assessment of importance of groundwater abstraction in the whole country perspective;
3. assessment of ratio of groundwater exploitation for the whole hydrogeological rayon;
4. assessment of ratio of important concentrated groundwater abstraction sites and their exploitable amounts on the overall documented exploitable groundwater amounts within hydrogeological rayon.

The aim of such solution is to include all possible factors indicating worsening of groundwater quantitative status due to groundwater abstraction. In the step (1), the aim is to assess the certainty/uncertainty of quantified groundwater amounts within hydrogeological rayons (categories A, B, C, C1, C2, degrees I, II, III and estimate), as these values should enter the quantitative status evaluations with different ratings. Step (2) should bring into light the most important abstraction sites from the "whole country" point of view, as more consideration should be given to these sites of maximal groundwater exploitation. Steps (3) and (4) then represent the crucial steps in quantitative status evaluations.

Within the process of assessment of ratio of groundwater exploitation for the whole hydrogeological rayon – step (3) – the most important is the percentage (ratio) of groundwater abstraction from the exploitable groundwater amounts. Theoretically, if the exploitable groundwater amounts are correctly calculated, and they take into account all environmental needs, this ratio can be 100 %, i.e. all exploitable groundwater amounts can be abstracted without reaching the "bad quantitative status". The uncertainty within the process of calculation of exploitable groundwater amounts, mainly resulting from unclear ecological limits (needs of terrestrial ecosystems and surface water ecosystems bound to groundwater) causes, that individual EU member states reduce the “allowed” ratio of abstracted/exploitable groundwater amount somewhere in the interval between 30 % and 70 (80) %. This reduction should secure environmentally sustainable status of groundwater exploitation. In the case of Slovakia, 50 % abstracted/exploitable groundwater amount ratio is proposed as a threshold value for “quantitatively bad status” in regional assessments. Hydrogeological rayons and subsequently groundwater bodies with less than 50% abstraction should be considered in “conditionally” good status, as individual abstraction sites should be evaluated in further step (4).

Important groundwater abstraction sites are listed within the State Water Management Balance, part: Groundwater. Generally, for these sites exploitable groundwater amounts are calculated with higher accuracy than for other sites or regions. Generalization and averaging of quantitative status to the whole regions can result in a situation where the whole region is of “good quantitative status”, but inside, several abstraction sites cause a bad quantitative status locally. Assessments of quantitative groundwater status therefore should take into account individual exploited sites to avoid overlooking of real site problems by superficial averaging. Step (4) therefore introduces assessment of ratio of important concentrated groundwater abstraction sites and their exploitable amounts on the overall documented exploitable groundwater amounts within hydrogeological rayon. In some hydrogeological rayons, such concentrated abstraction sites can form even 80% of the total exploitable groundwater amounts and therefore play the most important role in the quantitative status evaluation. On the other hand, in the territories, where diffused groundwater sources exceed 50 – 70% of total exploitable groundwater amounts (i.e. only few important sites are under usage), the potential risk of overabstraction can grow as diffuse abstraction sites are not thoroughly evaluated within the State Water Balance report.

The master criteria for selecting groundwater bodies with “bad quantitative status” was therefore proposed as aggregation of overall abstraction/exploitable groundwater amounts for the whole groundwater body and presence of overexploited sites. If the ratio of abstraction and exploitable groundwater amounts exceeds 50% or if at least 2 abstraction sites with “emergency” or “critical” balance status (abstraction of more than 85% of exploitable groundwater amounts) occur on its territory, the “bad quantitative status” should be attributed to the whole groundwater body. For hydrogeological rayons with prevailing lower categories of exploitable amounts (categories “III.” and “estimate”), lower threshold for overall abstraction/exploitable groundwater amounts ratio was selected. If the sum of groundwater exploitable amounts in categories “III.” and “estimate” were higher than 25% of the total groundwater exploitable amounts for the whole hydrogeological rayon, i.e. the higher uncertainty degree of exploitable amounts knowledge was reached, the acceptable ratio of abstraction and exploitable groundwater amounts was decreased to 40%.

4.2 Methodology for quality pressures

The methodology of the qualitative evaluation of delineated groundwater bodies at risk is based on two aspects:

- Evaluation of present qualitative status of groundwater;
- Determination of potential risk owing to which groundwater does not reach "good chemical status".

4.2.1 Evaluation of present qualitative status of groundwater

Evaluation of the present qualitative status of groundwater in Slovakia is summarized in the Map of chemical status of groundwater bodies (Bodiš, 2003) created according to the following principles:

- Input data about chemical composition of groundwater consisted of 16 359 analyses from Geochemical Atlas (Bodiš, 1999). Samples were taken from springs, boreholes, wells, drainages and mine galleries. Because of the large number of samples the map is considered to be representative for the major part of Slovakia.
- The underlying data were divided into the previously delineated Pre-Quaternary and Quaternary groundwater bodies.

Subsequently the contamination index (Backman-Bodiš-Lahermo-Rapant-Tarvainen, 1998) was calculated. The contamination index makes use of the national drinking water limits (Regulation No. 151/2004 of the Ministry of Health). The reason for this is that in principle all groundwater should potentially be suitable for drinking water supply.
The contamination index for an individual component is calculated as follows:

$$C_{fi} = \frac{C_{Ai}}{C_{Ni}} - 1$$

C_{Ai} = analytical value of *i* - component

C_{Ni} = normative value of *i* – component

C_{fi} = contamination factor of *i* – component

Subsequently the contamination index for the analysed sample is calculated with the following formula:

$$C_d = \sum_{i=1}^{n} C_{fi}$$

C_d = contamination index of sample

C_{fi} = contamination factor of i - component

For the calculation of the contamination index of each sample, following input indicators of groundwater were used: total dissolved solids (TDS), NO_3, Cl, SO_4, As, F, Cd, Cu, Cr, Pb, Hg, Se, NH_4, Al, Mn, Zn, Fe, Na and Sb. If the contamination index of a sample is 1 or higher, the sample is labelled as "bad".

Subsequently for each delineated groundwater body, distribution of contamination indexes was calculated by kriging method. To assign a good or bad present status to the groundwater body the following methodology was used:

1. If a groundwater body consists of 50% of samples with a good status and 50% of samples with a bad chemical groundwater status, we consider the whole body has a bad chemical groundwater status;
2. If the percentage distribution is different the status is assigned according the prevailing chemical status higher than 50%;
3. in order to determine the status of a groundwater body at least 10 information points should be present.

4.2.2 Verification of the present status

Because sampling for geochemical mapping was realized in the period of 1991 – 1994 there was a need to verify the present status evaluation. This was done by a comparison with monitoring data from the SHMU monitoring network and SAVOMW database (WRI, Bratislava). The SAVOMW database contains analyses of drinking water quality delivered from Waterworks and Sewerages enterprises. Additionally the year 2002 results from the SHMU monitoring network have been used for comparison. The new points with calculated contamination indexes were compared with the status map. Results of this comparison showed a very good conformity. Results from SAVOMW database (November 2002) have been processed in a similar way and also showed good conformity with the Geochemical Atlas data. We therefore can conclude that the results from geochemical mapping also represent the present status and can be used as a basis for the evaluation of groundwater qualitative status in Slovakia.

4.2.3 Determination of potential risk

The potential risk of delineated groundwater bodies is estimated on the basis of an evaluation of the potential impacts of diffuse and point sources of pollution and the vulnerability of the groundwater bodies to pollution. The used approach takes into account and uses almost all available information within Slovakia. Used information layers (map layers) are:

- Land use classes (Corine Land Cover);
- Point sources of contamination (GeoEnviron system, WRI, SHMI);
- Groundwater quality map of Slovakia (completed with the objects from SHMI and WRI databases);
- Map of groundwater vulnerability (Malík, 2002).

Potential risk of diffuse sources of contamination

For the estimation of the potential risk of diffuse sources of contamination a classification of land use classes is used. From the land use classes potential load classes have been derived with potential low, moderate and high environmental load (Fig. 4.1). For an assessment of the potential pollution risk of the groundwater bodies , the potential loads were combined with the vulnerability of the groundwater bodies (see below). The intersection of these two layers is a map showing the potential risk for diffuse pollution sources.

The methodology has been verified briefly by comparing observed nitrate and phosphate concentrations with areas with a high risk. This comparison showed good matching results. Information about application of pesticides and their direct content in groundwater in the entire area of Slovakia does not exist.

Figure 4.1: Estimation of potential risk from diffuse sources

Potential load of diffuse sources

Land use classes	**Potential load**
Others	Low 1.
arable land meadows and pastures	Moderate 2.
urban fabric industrial, commercial and transport areas mine, landfill and construction areas	High 3.

→

Vulnerability
Low I.
Moderate II.
High III.

→

Potential risk of diffuse s

Diff.source vulnerability	**1.**	**2.**	
I.	1	2	
II.	1	2	
III.	2	3	

Potential risk of point sources of pollution

Evaluation of potential risk point sources for whole area of Slovakia is the most complex processed by GeoEnviron system. The GeoEnviron is a database that contains about 8000 potential point sources of pollution such as:

- Database of landfills created and updated at Informatics department of Geological Survey (processed by SHMI)
- IPKZ database and questionnaires (processed by SHMI)
- Database of pollution sources from HEP (processed by WRI)
- Database of pollution sources previously processed by GeoEnviron (processed by WRI)

This system contains also methodology for evaluation of potential risk point sources by means of final risk score. In annex E it is elaborates how the GeoEnviron assigns a risk score to the individual point sources.

Vulnerability map

The vulnerability map indicates the possibility of pollutants leaking into the groundwater and is used for evaluation of the potential risk for diffuse and point sources. The following factors were used to create a groundwater vulnerability map (scale 1 : 500 000, Malík, 2002):

1. permeability of rock environment given by its permeability coefficient;
2. thickness of unsaturated zone given by difference between terrain level and level of the highest part of first aquifer under terrain.

On this basis evaluation of groundwater vulnerability according to the vulnerability coefficient Z has been elaborated:

$$Z = -150 \; (\log k \, . \, h)^{-1}$$

where:

k –average permeability coefficient of rock complex [$m.s^{-1}$]

h – average depth of groundwater below surface level [m]

Total score of groundwater vulnerability range from 2 $s.m^{-2}$ to 22 $s.m^{-2}$. Rock complexes with $Z > 11$ $s.m^{-2}$ are considered as regions with high vulnerability, with no or very low natural groundwater protection. Middle natural groundwater protection, resp. moderate vulnerability has been assigned to the rock environment with final score of Z vulnerability coefficient from 7 $s.m^{-2}$ to 11 $s.m^{-2}$. Regions with good natural protective function of unsaturated zone and hence low groundwater vulnerability have final value $Z < 7$ $s.m^{-2}$. The vulnerability map is included in Annex D.

Potential cumulative risk diffuse and point sources
Potential risk from diffuse and point sources of contamination were identified by described procedure and in the last step, final layer is compared with present groundwater quality map of Slovakia.
According the scheme shown in figure 4.2 the final map with delineated groundwater bodies and their risk for pollution was produced (see annex D for the result).
Identification of potential cumulative risk resp. not reaching of good chemical status of groundwater body represents bodies with following criteria:

- present poor groundwater quality according to the map of present qualitative status;
- low, moderate and high potential cumulative risk of point (overlapping with diffuse) and diffuse sources of pollution according to they potential impact and properties of aquifer (vulnerability).

Figure 4.2 Evaluation of risk for qualitative pressures

	Chemical status	
Potential risk	0 Good	1 Bad
1 Low	0.	1.
2 Moderate	0.	1.
3 High	1.	1.

4.3 Transboundary groundwater bodies/geothermal groundwater bodies

From the total number of 12 groundwater bodies that are considered to be of transboundary interconnection, 8 are considered to be at quantitative or qualitative risk. Two of the groundwater bodies considered to be of transboundary are geothermal (SK300010FK Geothermal groundwater body of the Komárno high block and SK300020FK – Geothermal groundwater body of the Komárno marginal block).
3 of them are pre-Quaternary groundwater bodies:

1. SK200270KF: A dominant karst-fissured groundwater body of the Veľká Fatra, Chočské vrchy and Západné Tatry Mts. in the watershed area of Váh. This body crosses the borders with Poland and is also under quantitative risk.
2. SK200440KF ADominant karst-fissure groundwater body of the Tatry Mts. in the watershed area of Poprad and Dunajec and
3. SK200480KF – Dominant karst-fissure groundwater body of the Slovenský Kras Mts. in the watershed area of Hron and Hornád). This body crosses the border with Hungary and has a qualitative risk.

The remaining 7 groundwater bodies are Quaternary

1. SK1000100P – Intergranular groundwater body of the Vienna Basin Quaternary sediments in the Danube watershed area. This groundwater body crosses the borders with Austria there and is classified as an intergranular groundwater body of the Vienna Basin Quaternary sediments in the Danube watershed area under quantitative risk.
2. SK1000800P – Intergranular groundwater body of Quaternary sediments of the Ipeľ river in the Hron watershed area. This body crosses the border with Hungary and has a qualitative risk.;
3. SK1001500P – Intergranular groundwater body of Quaternary sediments of the S part of Bodrog watershed area. SK1001500P is under both quantitative and qualitative risk and lies on the both Ukrainian and Hungarian frontiers.
4. SK1000200P – Intergranular groundwater body of Quaternary sediments in the W part of the Danubian Basin in the Danube watershed area;
5. SK1000300P – Intergranular groundwater body of Quaternary sediments of the Danubian Basin in the Váh watershed area. This body crosses the border with Hungary..;
6. SK1000900P – Intergranular groundwater body of Quaternary sediments of the Rimava river and its tributaries in the Hron watershed area. This body crosses the border with Hungary.; and
7. SK1001100P – Intergranular groundwater body of Quaternary sediments of the Slaná river and its tributaries in the Hron watershed area)

The groundwater bodies with possible transboundary interconnection and under quantitative or qualitative risk are shown in figure 4.3

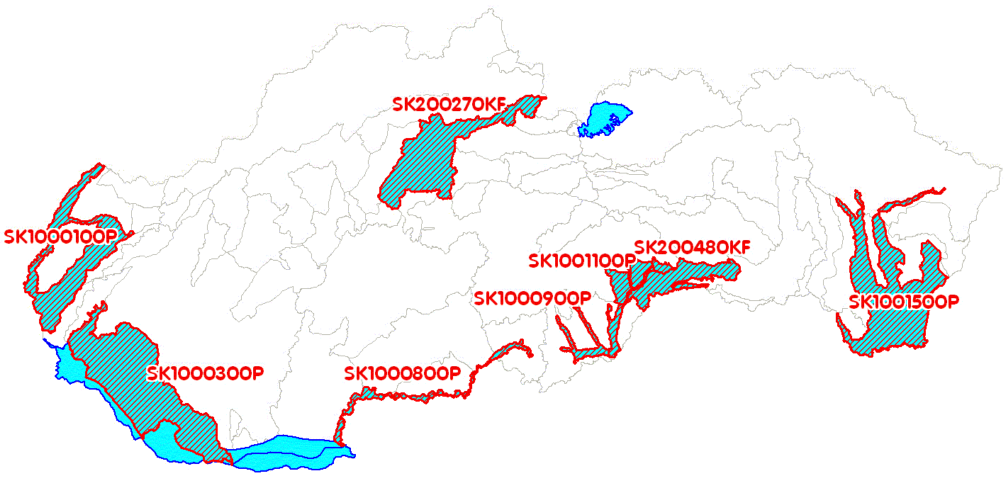

Figure 4.3 The groundwater bodies with possible transboundary interconnection, under quantitative or qualitative risk.

5 FURTHER CHARACTERIZATION OF GROUNDWATER BODIES AT RISK

5.1 Methodology for hydrogeological characterization of groundwater bodies

Further characterization of groundwater bodies at risk was performed on the base of data excerption from hydrogeological maps of the respective areas an – in the case of week coverage by hydrogeological maps - extrapolation of data. Groundwater bodies at risk were characterised by hydraulic conductivity (range, average), anisotropy, porosity (primary / secondary) & confinement. To keep the data comparable, they were stored in a database format and are presented in annex G.

Recharge areas of groundwater bodies at risk were not delineated for this purpose. Basically, in the process of delineation of hydrogeological rayons in 1974 and later (basic re-evaluation of the rayon boundaries were in 1984 and in 1996), the main goal of delineation was to include all parts of groundwater circuit into one rayon; i.e. recharge, accumulation and discharge should take place within one hydrogeological rayon. In this way, 141 hydrogeological rayons were created.

5.2 Groundwater system analysis

Recharge

Groundwater abstraction data are gathered by Slovak Hydrometeorological Institute (SHMU) due to the obligatory declarations by organizations using groundwater according to the valid Regulation of Ministry of Environment (No. 557/2002 dated on August 26, 2002 about the regulation practice of the Water Law). Recharge / drainage (by atmospheric precipitation or by surface streams) is not regularly reported for the whole country, and not for each hydrogeological rayon yet. Occasional hydrogeological investigations and prospecting carried out by hydrogeological consultants in some of rayons produced some values of effective precipitation (recharge by rain) ranging from approximately 5 $l.s^{-1}.km^{-2}$ to 22 $l.s^{-1}.km^{-2}$ were obtained for karstic structures, whereas in granitic or flysh rocks groundwater recharge is smaller (0.5 $l.s^{-1}.km^{-2}$ to 8 $l.s^{-1}.km^{-2}$).

Such systematic hydrogeological investigation were performed only in about 60 – 70 rayons, so the data do not cover all the country. Results for individual hydrogeological rayons are stored as manuscripts in the archive of the geological Survey of Slovak Republic, but are not systematically reported within the State Water Management Balance of Slovak Republic, part: Groundwater. Recharge of aquifers by rivers was also investigated only in several cases, and there is a lack of systematic knowledge on surface stream water – groundwater exchange and interaction covering all the country.

Exchange with neighbouring groundwater bodies (interconnectivity)
During the delineation process of hydrogeological rayons in 1974 and later (basic re-evaluation of the rayon boundaries were in 1984 and in 1996), the main goal of delineation was to include all parts of groundwater circuit into one rayon; i.e. recharge, accumulation and discharge should take place within one hydrogeological rayon. As the concept of creating groundwater bodies followed the concept of existing hydrogeological rayons, partial rayons and subrayons, created groundwater body was a mosaic consisting of several existing hydrogeological rayons, partial rayons and subrayons. In this way, recharge areas for groundwater bodies are situated within the bodies and no special linkage to other bodies is needed. However, some hydrogeological reports brought into light some new ideas about possible groundwater exchange between hydrogeological rayons, especially from the mountainous regions formed by the carbonate rocks (or sometimes also neovolcanitic rocks) downwards, feeding the aquifers in the large sedimentary basins. Those suspicions were not proven yet by systematic surveying, but more investigations in this field should be undertaken in the future.

Hydrogeological properties
Spatial distribution of groundwater and hydrogeological properties of rocks are under the scope of interests of Štátny geologický ústav Dionýza Štúra (Geological Survey of Slovak Republic; ŠGÚDŠ / GS SR). ŠGÚDŠ / GS SR Department of hydrogeology and geothermal energy produce hydrogeological maps in various scales. The whole country is covered by 12 sheets of hydrogeological maps in 1 : 200 000 and a hydrogeological overview map of 1 : 750 000 was published as well. Today, approximately 25 % of the Slovak territory is covered by basic hydrogeological maps in 1 : 50 000 scale. Maps in the scale of 1 : 50 000 are gradually produced, the latest version even on user-friendly CD version in HTML format to enable inspection of regional hydrogeological properties (and hydrogeochemical properties as well), and obtain basic parameters of individual springs and drilled wells.

Abstraction for drinking water
Abstracted groundwater, especially for drinking water supply, is under the scope of interest of Výskumný ústav vodného hospodárstva (Water Management Research Institute). Data gathering for monitoring purposes concentrates here especially on water quality; nevertheless, abstraction and discharge of exploited springs are stored here as well. Výskumný ústav vodného hospodárastva (Water Management Research Institute) also publishes sets of maps in 1 : 50 000 scale – set of “water management map” sheets and set of “water protection map” sheets, where the position of exploited sources and of their protection areas, together with other water management issues, are plotted. Groundwater abstraction data are gathered also by major groundwater users for public drinking water supply – regionally organized until now state waterworks companies: Západoslovenské, Severoslovenské, Stredoslovenské, Východoslovenské vodárne a kanalizácie (Western, Northern, Central and Eastern Slovakian Waterworks), today in the process of privatization. Nevertheless, those data are send to by Slovenský Hydrometeorologický ústav – Slovak Hydrometeorological Institute (SHMÚ / SHMI) and Výskumný ústav vodného hospodárstva (Water Management Research Institute) as well.

5.3 Verification of pressures on groundwater quantity (trend analysis)

Groundwater levels and especially their trends in time, possibly influenced by human activities, represent one of the important tools to select groundwater bodies under quantitative risk due to the European water framework directive. In the previous steps, (see 4.1) groundwater bodies under quantitative risk in Slovakia were selected due to the ratio of groundwater abstraction and exploitable amounts both in hydrogeological rayons and important abstraction sites. According to the results of the workshop at the end of the Project Phase I, analysis on data from observation wells monitored by Slovak Hydrometeorological Institute were proposed as the quality control / quality assurance step of the selection of groundwater bodies under quantitative risk.

Data, received on our request from Slovak Hydrometeorological Institute (SHMI) contained results of trend values from 116 springs and 806 wells. To create a compact comparable file, trend values were selected for the period of 1980 – 2003, counting 24 years of observation. Most of the monitored wells (802 in total) were situated by its screening in Quaternary sediments, mostly of river alluvia. Only 4 wells with sufficient time series (1980 – 2003) can be found in pre-Quaternary horizons. From 802 wells, belonging to the Quaternary monitoring network, only 687 monitored wells could be directly connected to Quaternary groundwater bodies, as 115 wells were localized in the smaller Quaternary alluvia connected with pre-Quaternary groundwater bodies. On the other hand, from delineated 59 pre-Quaternary bodies on the Slovak territory, only 31 contained at least one spring with sufficiently long observation time series (1980 – 2003).

Data of each well or spring contained its ID number in the SHMI catalogue, spring name or the well site, starting value of the simple linear trend line (in 1980), end value of the simple linear trend line (in 2003), average value of groundwater level (in meters a.s.l.) or spring discharge (in $l.s^{-1}$) for the respective period (1980-2003), absolute minimums and maximums for the same period, and the standard deviation of the whole range of monitored values.

Two techniques were compared to evaluate increase / decrease trend of groundwater levels and spring discharges. In the first (A) method, trend values were compared with the values of measured extremes. The difference of the starting value of the simple linear trend line (in 1980) and end value of the simple linear trend line (in 2003) was compared with the absolute range of maximal minus minimal observed value. The trend was evaluated as significant if the aforementioned ratio exceeded 50%.

In the second (B) method, trend values were compared with the values of standard deviations. If the difference of the starting value of the simple linear trend line (in 1980) and end value of the simple linear trend line (in 2003) exceeded the value of the standard deviation multiplied by 2, the trend was evaluated as significant.

In comparison of (A) and (B) methods nearly the same results were obtained on the whole territory of Slovak Republic both in spring and wells datasets.

In the following step, individual values of trend evaluation were linked to the respective groundwater body. Spring discharge trends dataset was used to evaluate pre-Quaternary groundwater bodies, trends of piezometric level in wells dataset was used to evaluate Quaternary groundwater bodies. 4 wells from the pre-Quaternary network were added to the spring dataset to evaluate pre-Quaternary groundwater bodies. Results of trends on the individual springs and boreholes were categorized to receive a clear meaning. 5 categories were created according to the ratio of the difference of the starting value of the simple linear trend line (in 1980) and end value of the simple linear trend line (in 2003) and the value of the standard deviation, as shown in Table 5.1. To each category, individual weight from -3 to 3 was given to count points for the whole groundwater body.

Table 1. Categories of the ratio of the difference of the starting value of the simple linear trend line (in 1980) and end value of the simple linear trend line (in 2003) and the value of the standard deviation of observed piezometric heads and spring discharges. Individual weights used for groundwater bodies' evaluation.

category No.	trend 1980-2003 / standard deviation (σ) value	weight
1	> 2 * **σ**	**+3**
2	> 1* **σ** and < **σ**	**+1**
3	> -1* **σ** and < 1 * **σ**	**0**
4	> -2* **σ** and < -1 * **σ**	**-1**
5	< -2* **σ**	**-3**

In the step of regionalization of the trend values, all individual weights belonging to the respective groundwater body were summarized and the final value was evaluated. The result of this evaluation is included in annex G.

5.4 Verification of pressures on groundwater quality (loads from agrochemicals)

As already mentioned in section 4.2, potential risk assessment from diffusion sources of contamination was realized on the base of Corine Land use model. Diffuse contamination sources are common in the lowland regions of Slovakia with highly developed agricultural activities. Therefore it is strongly required to verify their effect on the groundwater quality Generally, there are two options for verification. The first approach represents an assessment of the applied quantity of agrochemicals – pesticides and fertilizers. They represent a (quantified) potential risk to the soil. The second approach is assessing the direct impact to groundwater quality by measuring the main components of NPK-fertilizer (real information on pesticide contents in groundwater are insufficient).

The crucial criterion for selecting of the best method was the quantity and quality of the basic data. We decided to use the second approach and used nitrate and phosphate contents in groundwater of Quaternary bodies. In case of nitrates, the values above the standard (50 $mg.l^{-1}$) were figured. No threshold value was available for phosphates in Slovakia or the EU. Therefore, we used statistically calculated concentrations for their assessment – the upper interval limit represents 75 percentile and the lower interval limit 25 percentile. The maps are included in annex G.

From the assessment we may conclude that the Quaternary groundwater bodies show high concentrations in nitrate and phosphate distribution. It is obvious that fertilization represents a real risk to contamination of groundwater in condition of Slovakia.

Comment: Aaron: Little attention has been paid to this aspect during the project. I propose not to include this item in the

6 MONITORING

6.1 Present status of the groundwater quality monitoring network

Since 1998 SHMU operates a groundwater quality monitoring network, The wells are monitored with a frequency of once a year. All wells are on-screen wells which are monitored for a wide range of elements;

- Major components;
- Trace elements;
- Pesticides;
- Hydrocarbons.

A full list of monitored elements is included in annex H. When the present monitoring network is compared with the delineated groundwater bodies (see table 5.1) it becomes clear that not all bodies are being monitored at present. We expect that there are sufficient other well types which can be used to expand the present monitoring network. A map of the present quality monitoring network is included in Annex J.

Table 6.1 present distribution of monitoring points among groundwater bodies

	Quaternary groundwater bodies	Pre-Quaternary groundwater bodies
total groundwater bodies	16	59
total wells	222	116
bodies without wells	2	26
minimum density (wells/1000 km2)	10	0.5
maximum density (wells/1000 km2)	116	29
average density (wells/1000 km2)	21	3

6.2 Present status of the groundwater quantity monitoring network

Quantity monitoring can be divided into 3 types: extractions, levels and springs.

Monitoring of groundwater extraction

Groundwater extractions are recorded when abstraction exceeds 1250 m3 per month, or 15000 m3 per year, or if artesian groundwater is exploited. The extraction figures are collected monthly and reported as a yearly average in the report called "Štátna vodohospodárska bilancia Slovenskej republiky – časť Podzemné vody" by SHMU.

Monitoring of groundwater levels
Systematic of groundwater levels started in 1960. In total 2304 groundwater level monitoring wells were monitored, of which 1539 were a part of the „basic“ network, which were monitored for a continuous period. 765 wells were designed for special projects and have not been monitored continuously. Only a small number (about 100) of the monitoring network has been installed in the Pre-Quaternary aquifers. 806 wells have been monitored uninterrupted for 25 years in a row. At present 1391 are observed, of which 321 with digital loggers. Levels are yearly published in “Hydrologická ročenka. Podzemné vody” by SHMU.

Monitoring of springs
In total 1112 springs monitored of which 117 uninterrupted for 25 years. At present 432 springs monitored, of which 61 on a daily. Springs could be used in the future for an estimation of both the quality and quantity status.

A map of monitoring points is included in Annex K.

6.3 From present monitoring practice to monitoring for the WFD

To estimate to what extent the present monitoring network can be used for monitoring in the WFD, monitoring the current monitoring practice in the pilot area Zahorie was analysed in more detail.

According to the WFD art 8 surveillance monitoring is required for all groundwater bodies and operational monitoring for groundwater bodies at risk. Although at some locations in the pilot area Zahorie there may be problems with groundwater abstractions, the overall picture seems not bad. In most observation wells there is an increase in groundwater level or hydraulic head. However significant damage to terrestrial ecosystems directly depending on the groundwater body do occur locally in the pilot area. The chemical status of the groundwater body appears to be at risk due to high input of N and P from agriculture and waste water from households (40% is not connected to the sewage system). High levels of Fe and Mn are also found but are likely to be from natural origin. Furthermore many point sources of Cr are found related to former industrial activities.

Monitoring networks
In figure 1 the monitoring network is shown for groundwater quantity and figure 2 shows the monitoring network for groundwater quality.

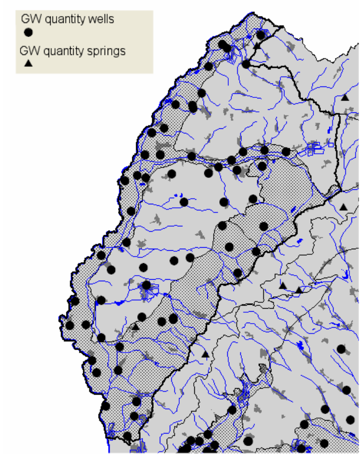

Figure 6.1

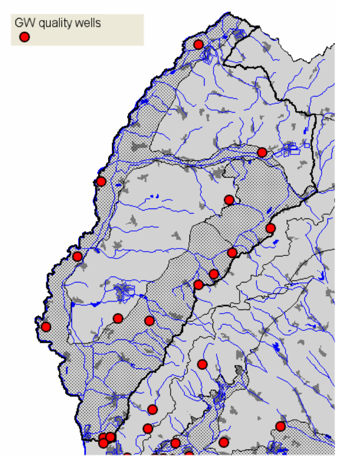

Figure 6.2

The monitoring network for surveillance monitoring of the quantitative status seems sufficient. However, most filters of the observation wells are concentrated in depth (5-15 m below surface level). The monitoring network for surveillance monitoring of the chemical status is less dense and not well distributed. Therefore it is likely to be insufficient for surveillance monitoring. The monitoring system could easily be extended by incorporation the raw water analyses of groundwater abstraction wells.

For operational monitoring of the chemical status the present system is insufficient. More insight is needed in the vertical and horizontal distribution of pollutants in the groundwater body. Especially for NO_3 a monitoring system is needed with filters on different depths to get more insight in the pathways and chemical transformations of nitrogen compounds.

7 NUMERICAL FLOW MODELLING

It is recommended to include numerical flow modelling as a tool in the process of groundwater evaluation. The main purpose of a numerical flow model is to establish a conceptual model of the hydrogeological systems. Once the hydrogeological systems are defined, the groundwater flow regime can be quantified in terms of volumes and direction of flow. The model is an ideal tool to guide the data collection process and can be used to deliver the results mentioned above.

7.1 The modelling process

During the development of the model three phases are distinguished: data gathering, model setup and model application.

Data gathering includes all data necessary to run the model. This data includes:
- The hydrogeological schematisation, or the identification of aquifers/aquitards and geological structures.

- Parameters governing groundwater flow; permeability, anisotropy (especially in karstic/fissure aquifers), primary and secondary porosity. Where primary porosity is often associated with Quaternary deposits (unconsolidated sand) and secondary porosity is associated with fissures and karst
- Precipitation, evaporation, surface runoff and recharge rates
- Groundwater abstraction (location and abstraction rate)
- Hydromorphology of rivers and streams
- Calibration data such as measured groundwater levels and fluxes in/from rivers
- Surface elevations (Digital Terrain Model)

For transboundary groundwater bodies, the data needs to be collected from neighbouring countries as well.

Using the data a mathematical flow model is built. The model is calibrated using piezometric levels from existing hydrogeological maps and point measurements from the groundwater monitoring network of SHMU.

The calibrated model can be used to carry out a hydrogeologcial system analysis to:
- Determine the direction of flow within the groundwater body
- Quantify the exchange of water between de groundwater body and associated surface water systems
- Determine and quantify possible transboundary and/or interconnected fluxes
- Identify recharge/infiltration areas and seepage/discharge areas
- Identify terrestrial and surface water ecosystems that are directly groundwater dependent
- Evaluation of the current monitoring system with respect to the WFD
- Review human impact on the groundwater body and changes regarding groundwater levels and pollution
- Quantify human impacts such as groundwater abstraction and pollution
- Linking of pollution (point and diffuse) to groundwater dependent ecosystems
- Evaluation and optimization of monitoring network (both quantity and quality)

7.2 Level of detail

It is important to realize that a the setup of a detailed numerical flow model of the entire country is virtually impossible. For the purpose of the evaluation of groundwater bodies for the Water Framework Directive a first step would be to build initial regional models of the Quaternary and transboundary groundwater bodies at risk.
Such a regional model was built for the pilot area Zahorie with an average nodal distance of about 500 meter. The model covers an area of 2700 km^2 and consists of 17430 nodes, 34630 triangular elements, 2 aquifers (Quaternary and Pre-Quaternary), 1027 groundwater abstactions and 177 rivers and streams. With this model it is possible to identify the main hydrogeological systems, quantify the groundwater dependency of eco-systems and surface water bodies and quantify the transboundary flux. Also, the exisiting monitoring networks can be evaluated and optimized. Further detailing of the regional model will be necessary for the evaluation of individual measures and design of investigative monitoring networks.

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ANNEX A
INSTITUTIONAL SETTING

INTRODUCTION

In Slovakia there is not *one* organisation responsible for groundwater management. By studying the tasks and duties of the most relevant national and regional authorities, it becomes clear that several of these organisations are dealing with groundwater issues. Considering the possible results of the project 'Evaluation of groundwater conform WFD requirements for groundwater management in Slovakia (MAT03/SK/9/3)' it makes sense to describe duties, tasks and position of these organisations and to describe the procedures of groundwater management.

The next paragraph focuses on the activities of the organisations, which have to do with groundwater management:

- Ministry of the Environment (Water Division);
- Slovak Hydro-Meteorological Institute (SHMI);
- Water Research Institute (WRI);
- Slovak Water Management Enterprise (SWE);
- Geological Survey (GS);
- Regional Environmental Offices;
- District Environmental Offices;
- Slovak Inspection of Environment (SIE);
- Waterworks and Sewerage Companies (WSaS);
- Slovak Environmental Agency (SEA);
- Ministry of Health (MoH).

ORGANIZATIONS

<u>Ministry of the Environment (Water Division)</u>

Ministry of the Environment (Water Division) is the central body of the state administration for water protection and its rational utilization, water management, public water supply, wastewater collection and treatment and fishing. Main tasks of the ministry in the field of water management are as follows:

- Carries out a state water administration in line with water act No.364/2004 and supervises its execution;
- Supervises the local state water administration carried out by regional environmental offices and district environmental offices;
- Provides harmonization of the national legal system with the EU legislation;
- Fulfils the tasks resulting from international treaties and agreements and cooperates with the neighbouring countries on the protection of transboundary rivers;
- Provides observation and assessment of surface water and groundwater;
- Carries out the National Monitoring Programme in the field of water quality and quantity;
- Provides development of Water Plan of Slovakia and water management plans of river basins;
- Centrally coordinates activities related to administration and operation of water courses and water structures in the ownership of the state;
- Centrally controls activities related to administration and operation of public water supply and public sewerage system;
- Elaborates conceptions and programmes for custody of water courses, utilization of hydro-energetic potential of water courses, supplying of inhabitants with drinking water through public water supply and waste water collection by means of public sewerage system;

- Fulfils the tasks related to flood protection;
- Regularly re-evaluates designated sensitive and vulnerable areas;
- Elaborates programme for decreasing of water pollution by dangerous substances.

The ministry was also responsible for the process of the Slovak Republic's accession to the EU under the chapter Environment.

Though not always explicitly described the legal tasks of the MoE make clear that the care of good groundwater is part of their duty. Groundwater management has quantitative (e.g. supplying enough drinking water to inhabitants) and qualitative aspects (e.g. prevention of pollution).

The current project focuses on both aspects of groundwater management. The methodology to recognize groundwater bodies at risk is based on quantitative as well as on qualitative aspects.

To fulfil the legal tasks of the ministry in an adequate way the MoE needs a good overview of the state of water, groundwater as well as surface water, in a qualitative and quantitative way. Therefore the Slovak Hydrometeorological Institute (SHMI) is presenting all relevant data of ground- and surface water in an accessible way by means of the annual State Water Management Balance.

Slovak Water Management Enterprise (SWE)
The WFD is based on two basic thoughts: sustainable use of surface- and groundwater and cohesion in water systems, which leads to the choice to assign the management of water systems to river basin authorities. This choice matches very well with the existing situation in Slovakia.
The Slovak Water Management Enterprise with the central office in Banská Stiavnica was established as the state entity in 1997. All former River Basin Administrations – public beneficial organizations were merged into this state enterprise and they now constitute 4 branch offices (River basin enterprises – RBE's). Each branch office is subdivided into about 5 local offices, responsible for operational management of the water system.
SWE provides the following tasks:

- Administration, maintenance and operation of water courses, water management works, drainage and irrigation equipments;
- Surface water supply of all branches of national economy;
- Protection against harmful effects of water;
- Water quality monitoring of surface water and water used for irrigation, measures for water protection including measures against accidental pollution; This water quality monitoring takes place in addition to the water quality monitoring carried out by SHMI.
- Condition developing for hydro energy potential utilization and conditions for water transport;
- Monitoring and evaluation of (ground- and surface water quality), together with water abstraction, waste water discharging and other dealings with waters;
- Drawing up the plan of complex care about water quality, planning of measures for surface water quality improving.

Operations are financed from the SWE resources, which are received from the sale of the surface water and from rent. The state subsidies are necessary and are used for flood protection. The SWE also collects payments for discharge of the wastewater into the watercourses. However, these payments are directly added to the State budget. SWE administers only watercourses important from the point of view of water management, watercourses allocated for drinking water supply, small streams up to the border of forests and drainage and irrigation channels. Other watercourses are in administration of the State forestry Enterprise and Army Organizations.

The SWE has no explicit tasks in the field of groundwater. Although indirect the role of good groundwater management is evident. There is a clear relation between surface water systems and groundwater systems. Abstraction of groundwater can influence surface water and the other way around e.g. heavy pollution of surface water may influence (on the long run) the quality of groundwater.

<u>State Regional and District Offices</u>
According to Law nr 525/2003 there are established regional environmental offices and district environmental offices providing local state administration for environment. Main functions of these offices involve decision-making, licensing, control and supervising. These offices are directly supervised by the MoE.

<u>Regional offices</u>
In Slovakia there are 8 Regional environmental offices. They issue permits at the first level of state water administration in the case of international waters or transboundary waters, or if water structure covers or influences territory of two or more districts. For all other matters the permits are distributed by the District office. In case a private party disagrees with the District office about the issued permit, the Regional office will deal with the case (2^{nd} level).

In harmony with Water Act No. 364/2004 a regional office can through a regulation designate selected water bodies for bathing of public, for irrigation, and for fish life and its reproduction, and it can make decision about using of water for navigation.
The offices cooperate with other bodies of state administration and other organizations.

Additional information gathered during discussion with Mr Wendl of Regional office Bratislava:
The regional office has little influence on the drafting of the River Basin Management Plan (RBMP). This task is carried out by the RBE's. District and Regional office will carry out legislative duties on the basis of the RBMP.
At the moment some of the tasks of the Regional office are transferred to the Slovak Inspection of Environment (SIE). According to Mr Wendl this causes a less effective law enforcement.
According information given by the Bratislava Water Works the regional office checks the groundwater quality around the drinking water wells. This information is sent by the Waterworks to the regional office.

<u>District offices</u>

In Slovakia there are 46 District environmental offices. They act as state water administration at the first level - they are in charge of decisions with respect to water and environment and serve as the special construction service for water related structures. In compliance with water act No.364/2004 the district offices permit the application of dangerous substances for special purposes, keep inventory on waters, issue information on wastewater and sludge disposal, and through a regulation it may change or limit the water utilizations and area of inundation.

As state water administration units these organisations are responsible for licensing, control and supervising of use and pollution of waters. For abstraction of groundwater (drinking water) companies need a license provided by the (regional or) district office. Also the district office is responsible for licensing waste water treatment plants for their disposal water and individual households and companies for their connection to the sewage system. The results of the current project (groundwater bodies at risk) could be a reference for the authority to provide a license or not.

To be complete also other organisations have to be mentioned which work is indirectly related to groundwater management: Slovak Inspection of Environment, Slovak Environmental Agency, the Waterworks and Sewerage Companies and the Ministry of Health.

Additional Information gathered during discussion with staff of Skalica District office:

- District office is also responsible for some tasks within protected zones (deciding about permits for activities within these zones and exerting control on unlawful activities.
- The district office assigns the groundwater protection zones around drinking water wells.
- Permit for groundwater abstraction are only given to the applicant after a hydrogeologic study has been carried out from which it is evident that the extracted amounts do not cause adverse effects on the surroundings or cause depletion of the aquifer.
- SHMI carries out the monitoring activities and warns the district office in case the groundwater quality or quantity is insufficient.. *According the district office the present monitoring effort is not sufficient for the district office to carry out its tasks properly*
- At present the district office decides to take measures on the basis of what is visible above the ground (spills and other activities) and not on monitoring results
- 40 % of the households are not connected to a sewage.
- Within the area mainly agriculture and an oil refinery cause bad groundwater quality.
- *The district office has not been informed by the MoE about the WFD, has not been consulted during the previous reporting period and is not aware of its new tasks that may follow as a result of the WFD.*

Slovak Inspection of Environment (SIE)
It is a state administrative body for the protection of environment. The Inspection is a professional body through which the Ministry of Environment performs the state professional supervision. The action of the Inspection is separated into four departments, namely water management inspection, air protection inspection, waste management inspection, and nature protection inspection. The headquarters are in Bratislava. The Water Inspection Centres are located in 5 towns (Bratislava, Nitra, Zilina, Banska Bystrica, Kosice). The territorial activity of each centre with respect to water management inspection is determined according to the area of river basins. The Inspection exerts the supervision in extent and under conditions given by relevant acts and by the Ministry of Environment. The Inspection also imposes penalties for law infringement. The Inspection is financed from the State Budget.

Waterworks and Sewerage Companies (WSaS)
The state companies of Waterworks and Sewerage provide the following tasks:
- Drinking water supply of inhabitants and other consumers;
- Collection of wastewater by means of public sewerage network and treatment of wastewaters;
- Water resources development, technical and investment development in sanitary engineering.

Five Waterworks and Sewerage Companies were established in Slovakia. Due to the regulated prices for drinking and sewage water for inhabitants, the WSaS companies are operating in some regions at a loss and in others at a profit. In general, the WSaS companies are able to cover their own operational costs. There are large investments needed to build new Wastewater Treatment Plants (WWTPs). Therefore municipalities are trying to build new sewerage systems and WWTPs independently from the WSaS companies. The WSaS companies are in a process of transformation. The main purpose is to bring assets and responsibilities to the municipalities. This process started in the second half of the year 1997 and until today it is not finished.

Additional information given by Bratislava Water Works: big investments are expected in order to reduce N/P loads in the treated waste water. They expect that Europe will contribute to these project financially, and don't expect a significant rise in the cost for the citizens as a result of the WFD requirements. The Bratislava water works indicate that the groundwater quality in the Zahory region is generally bad due to naturally occurring Fe/Mn. Only in one case they had to close a well as a result of high nitrate levels originating from agriculture. Once the groundwater quality is below standards, they normally close the well and transport the water by a pipeline from Bratislava or a neighbouring well.

<u>Slovak Environmental Agency (SEA)</u>
Initial Provision: The Slovak Environmental Agency has been established by the decision of the Minister of the Environment of the Slovak Republic from 17 May 1993, No. 8/1993, issued pursuant to § 28 of the Law No. 567/1992 Coll. on Budgetary Rules of the Slovak Republic, as amended, and § 2 letter g) of the Law No. 595/1990 Coll. on the State Environmental Administration. By the decision of the Minister from 19 December 2000 No. 2118/2000-min. the full wording of the founder's deed of the Slovak Environmental Agency was issued because of the change of the form of the Slovak Environmental Agency's financial management. The Slovak Environmental Agency is a semi-budgetary organisation established by the Ministry of the Environment of the Slovak Republic; its headquarters are in Banská Bystrica.

Activities: The Slovak Environmental Agency is a scientific organisation operating on the territory of the whole Slovakia. The activity is focused on the environmental protection, environmental policy development and landscape creation on the principles of sustainable development.

Extract of spheres of activity:

- General and cross-sectional activities in all professional fields:
  - State of the environment evaluation and environmental regional classification;
  - Monitors, collects, processes and evaluates environmental situation on the regional and national level and harmonises selected environmental indicators with international indicators (*Check if this action is done either on the basis of a fixed Monitoring Network or on a ad-hoc basis)*;
  - Co-ordinates works connected with the reporting process to EEA, OECD and EU;
  - Works out annual draft Report on the State of Environment of the Slovak Republic.
- Environmental impact assessment:
  - Develops expert opinions on the installations, constructions and other activities, which are being prepared, pursuant to the Act of the National Council of the SR No. 127/1994 Coll. on Environmental Impact Assessment for a competent body, intentions and reports on EIA pursuant to the given Act;
  - Develops expert opinions for the evaluation of draft development concepts, draft development plans of regions and selected residential areas of selected towns;
  - Participates in the evaluation and negotiation of draft generally binding legal regulations from the point of view of their expected impact on the environment;
  - Builds up and operates the Documentation Centre.
- Optimisation of spatial arrangement and functional use of urban and rural landscape, its creation and protection:
  - Provides for analyses, draft concepts and complex and optimum solution of spatial arrangement and functional use of the landscape, suggests its principles, objective and co-ordination of activities affecting environment, ecological stability and cultural-historical values of landscape;
  - Executes transferred activities connected with MoE competencies, such as the operation of executive secretariats for the Village Restoration Programme and international co-operation;
  - Monitors and evaluates the carrying capacity of the land in relation to risk factors and suggests principles of natural resources use.
- Environmental risks and environmental safety:
  - Builds up and operates the Data Centre as the depository of data, methods and models connected with the environmental risk assessment;

- Develops analyses of environmental impacts, their chemical, physical and biological factors on human health and suggests preventive and corrective measures to minimise negative impacts;
- Builds up and operates the Information System of Major Industrial Accidents Prevention in the conditions of the Slovak Republic.

The Ministry of Health (MoH)
The MoH is the central authority of the state administration for health care, protection of the public health and health information systems.
The body of public health protection of the Ministry of Health designates the Chief Hygienist of the Slovak Republic. The chief hygienist designates and directly controls the Regional Hygienists and also manages the District Hygienists situated in the District Office. The appeal authority for decisions made by the District Hygienists is the Regional Hygienist.
The Hygienic Service Authority sets the quality requirements of drinking water and evaluates the construction works within the water sector. The Hygienic Service Authority evaluates proposals for zones of hygienic water protection. The authority controls results of water analyses carried out by the operators of public water supply companies and sets the conditions for utilisation of water in recreational areas.

This ‘walk’ through the Slovak public organisations makes clear that there is a strong relation between the activities of the individual organisations as far as groundwater management concerns. The next paragraph emphasizes the institutional aspects of the Water Framework Directive (WFD) and the effects of the WFD on the Slovak Water Act.

Slovak Hydro-Meteorological Institute (SHMI)
The basic objective of the Slovak Hydrometeorological Institute is to obtain, process, interpret and store the data on the state and regime of water and air. The SHMI acts in three areas, in the area of hydrology, in the area meteorology and climatology and in the area of monitoring of air quality. SHMI is responsible for 3 partial monitoring programmes, namely “Water”, “Meteorology and Climatology” and “Natural Radiation”. In addition it provides activities resulting from requirements for hydrological forecast service in the area of Slovakia and Danube river basin (PIAC). The SHMI has its headquarters in Bratislava and 3 regional offices in cities Kosice, Zilina and Banska Bystrica. The SHMI is a contributory institution - partly financed from the state budget. Everyone who withdraws groundwater in an amount, which exceeds the amount determined by law, is obliged to report quantity and quality of withdrawn water to the SHMI. SHMI elaborates yearly report on State Water Management Balance, coordinates preparation of Hydro-ecological Plans and elaborates selected parts of these plans itself.

For the current project in particular the division Hydrological Service is important. This division is carrying out comprehensive operational, R&D activities in the area of water quantity and quality monitoring and assessment. They include:

- Measurement, processing, assessment and archiving of quantitative and qualitative hydrosphere parameters;
- Operation and development of monitoring networks;
- Surface water courses forecasts and warnings – hydrological forecasting service;
- Discharged wastewater quantity and quality assessment;
- Operation and development of database systems and the GIS applications;
- Standardisation activities in the area of hydrology and water management and the preparation of background papers for legal regulations concerning water protection in the Slovak Republic;
- Processing of hydrological and water management balance of the Slovak Republic;
- Development of hydro-ecological plans for catchments;
- Pesticide programme for water system protection;
- Operation of the Pinkovce (on river Uh) warning and monitoring station (water quality);
- Providing the Slovak Republic's international cooperation and international obligations on hydrology;
- Expertise and advisory on hydrology.

SHMI has explicit tasks to fulfil in the field of groundwater management. The MoE was designating the SHMI to be the direct beneficiary for this groundwater project. The head of Groundwater Department is direct counterpart of the Consultant for the current project.

<u>Water Research Institute (WRI)</u>
WRI provides research in hydrology, hydraulics, drinking water treatment technology, wastewater treatment, and quality of surface and groundwater and water analyses. WRI also elaborates regional projects on water resources development and water balances. Other activities dealt are with the standardization, legislation, computer technique, international cooperation and drawing up studies for elaboration of the water management strategy. The WRI was designated by the Slovak Government to act as the National Reference Laboratory and to function as the methodological centre for analytical water examination, determination of sediments, sludge, and chemicals which being in contact with water.

In particular because of the role of WRI in the field of groundwater quality there is a clear relation with groundwater management and the purposes of the current project.

<u>Geological Survey (GS)</u>
The Geological Survey of Slovak Republic, as a ministerial scientific research institute, is a contributory organisation that guarantees geological research and exploration of the territory of Slovak Republic, creation of information system in geology, recording and registering of geological works performance, collects, records and makes available the results of geological works carried out within Slovak Republic, function as a central geological library and edition and sale of maps and professional geological publications.

Main tasks of GS are:

a. Systematic and complex research of the territory of Slovak Republic aiming on:
   - research, evaluation, documenting and delineation of the lawfulness of geologic development and geological setting of the territory, geological mapping including compiling and approbation of geological and thematic purpose maps and functions as supervisor in these activities;

   - hydrogeologic research and compiling of hydrogeological, hydrogeochemical and geothermal maps, evaluation of groundwater sources, geothermal, mineral curative and table waters, evaluation of negative influences on their quality and quantity, as well as providing a groundwork for their reasonable utilisation;

   - engineering geological research and compiling of engineering geological maps aiming on verification of engineering geological and geotechnical conditions of the territory, mainly for purposes of land use planning, urbanism, monitoring and documenting of harmful geodynamic processes (landsliding, erosion, weathering, etc.) with consequent suggestions for their stabilisation and treatment;

   - research and evaluation of geological factors influencing the environment, triggered by human activities, discovering and evaluation of antropogeneous contamination of geologic environment, soils and waters including their monitoring and compilation of maps of geological factors of environment;

   - research into geological structures suitable for final storage of radioactive and toxic wastes, gases and liquids within the natural rock environment and underground spaces and research into industrial utilisation of geothermal energy;

   - research into lawfulness and distribution of raw material resources, their technological properties and economic utilisation, compilation of regional maps of raw materials and metallogeny maps and genetic models of deposits, prognosing evaluation of mineral resources, groundwater and geothermal energy.

b. Projection, performance and evaluation of geological works in the scope of raw material, hydrogeological, engineering geological exploration and within the investigation of geological factors of environment.

c. Projection, performance and evaluation of works in the scope of geophysical, geochemical and special-purpose research and exploration.

d. Performance and evaluation of chemical, physico-mechanical and other laboratory analyses of geological materials and matters of inorganic/organic origin contaminating geological environment.

e. Safeguarding the activities as a reference laboratory for geological sciences.

f. Follow-up, collection and processing of data on raw material resources and their exploitation, costs and conditions of their utilisation in Slovakia and abroad, monitoring of consumption and prices development and their application in conditions of Slovak Republic.
g. Safeguarding of obligations following from the Law of National Council of Slovak Republic No. 52/1988 of the Law Code on geological works and Slovak Geological Office in the wording of the Law of National Council of Slovak Republic No. 497/1991 of the Law Code and from the Law of National Council of Slovak Republic No. 44/1988 of the Law Code on the protection and utilisation of mineral resources, in wording of the Law of National Council of Slovak Republic No. 498/1991 of the Law Code on registers administration, management of exploration territories, administration of attests on exclusive deposits, administration of exclusive deposits resources and balance sources of mineral raw materials, management of register of old mining works, gathering, administration and making available of geological works results.
h. Creation and utilisation of information system in geology as an information subsystem on environment.
i. Function as the central geological library of Slovak Republic, performance of objective expertise, lecturer, consulting and advisory activities.
j. Elaboration of groundwork and information on possibilities of enterprise in geological works, utilisation of raw materials, groundwater and geothermal energy sources, protection and sustainable usage of rock environment and groundwater, for governmental institutions, inland and foreign investors.
k. Elaboration of groundwork to create concepts of geological research and exploration on the Slovak territory, as well as to provide suggestions of legislative standards in the field of geology addressed to the Ministry of Environment of Slovak Republic.

Giving these tasks it is obvious that the GS is playing a prominent role in the identification, characterization and evaluation of groundwater bodies, in fact the main objective of the current project.
The current project focuses on the groundwater bodies at risk. Therefore there is a need to understand the cohesion of groundwater bodies, to locate them and to characterize them. In this respect the GS has a duty to provide necessary information.

WATER FRAMEWORK DIRECTIVE (WFD) AND SLOVAK WATER ACT (SWA)

In article 3 of the WFD the co-ordination of administrative arrangements in river basin districts is highlighted. Member States shall identify the individual river basins lying within their national territory and assign them to individual river basin districts. Where groundwater does not fully follow a particular river basin, it shall be identified and assigned to the nearest or most appropriate river basin district or districts.

In 1997 the Slovak Water Management Enterprise (SWE) with the central office in Banska Stiavnica was established as the state entity. All former River Basin Administrations – public beneficial organizations – were merged into this state enterprise and they are now its branch offices (River Basin Enterprises – RBE's). In Slovakia there are 4 RBE's: Morava/Danube, Hron, Vah and Bodrog/Hornad.

It can be concluded that the administration of regional water management in Slovakia matches perfect with the WFD.

In 2002 the Slovak Parliament approved the Slovak Water Act. Currently the European Commission reviews this law, as they do with all new laws in Member States, and assesses if the European Water Directives (e.g. the WFD) are correctly transposed in this new law.

In fact there are no big changes between the current Slovak Water Act and the previous one. The responsibilities of Slovak Hydrometeorological Institute, River Basin Enterprises and the environmental departments of the Regional and District Offices are better described in the new law. The SWA makes clear that the Ministry of the Environment (MoE) is responsible for the establishment of Water Management Plans in each river basin. The MoE assigned this task to the River Basin Enterprises, which is fully in compliance with the WFD (article 13). However, the SWA doesn't sufficiently clarify the responsibility of the measures described in the Water Management Plan. This might create problems in the stage of implementing the described measures, in particular in relation to their financial consequences.

Annex B
Results initial characterization

ACTIVITY 1.1 DELINEATION OF GROUNDWATER BODIES

Sub activity 1.1.1 Regional Hydrogeology

Result 1: Hydrogeological framework
General description of hydrogeology
Slovak hydrological and hydrogeological settings are extremely complex. Territory of the country is mostly built up by the West Carpathian Mountains. An extensive Alpine-type folding created a complex mountain system with a classical nappe structure, which is responsible for the great complexity of hydrogeological conditions of groundwater circulation to be found today. Several hydrogeological regions and units with different conditions of groundwater formation and circulation can be distinguished here with regard to the tectonic structure and structural-hydrogeological conditions. With regard to the complexity of geological structures and structural-hydrogeological settings of groundwater circulation, Slovak territory can be divided into the following hydrogeological complexes characterized by different conditions of the formation of groundwater chemical composition (see also Fig. 1):

- Crystalline unit;
- Palaeozoic;
- Mesozoic;
- Flysch Belt;
- Klippen Belt;
- Inner-Carpathian Palaeogene;
- Neogene sediments;
- Neogene volcanic;
- Quaternary.

Each of the above hydrogeological complexes is characterized by different amounts of groundwater, permeability, groundwater regimes and circulation controlled largely by the different mineralogic-petrographic character of the catchments, transport-accumulation and discharge sections of the hydrogeological cycle and has a distinctive groundwater composition. From a structural-geological point of view, the Inner West Carpathians are the most complicated. They typically contain cores of Palaeozoic and crystalline schists overlain by Mesozoic (Lower Triassic to Lower Cretaceous) shale-sandstone and carbonate lithofaces. The Inner Carpathian Palaeogene and the intrabasinal Neogene overlie these.

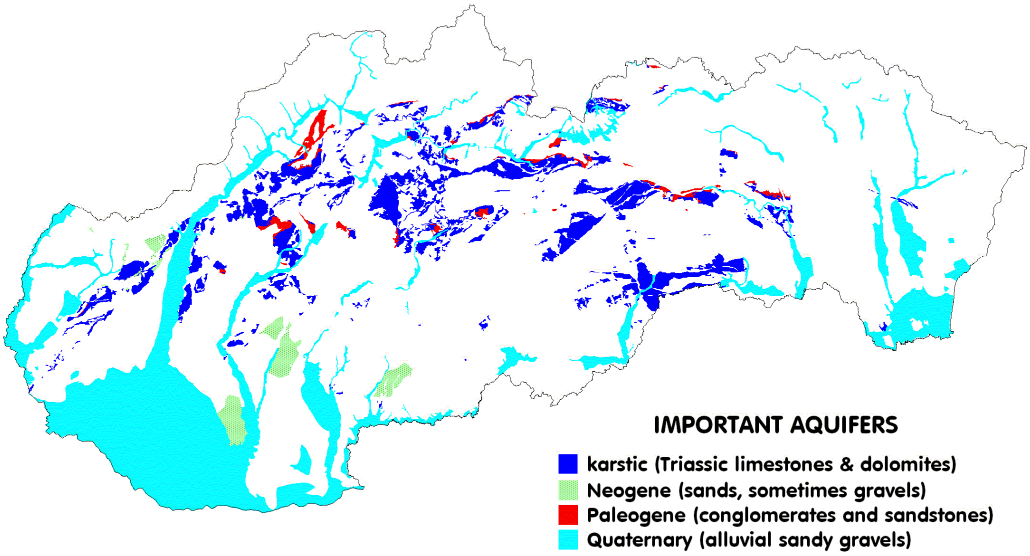
Groundwater circulation in the crystalline schists (area: 4 700 km^2), is bound to the zone of superficial weathering and fractured zones which extend to a depth of 50 - 60 m. Spring discharges are usually below 1 $l.s^{-1}$. Palaeozoic rocks in the Gemericum (flyschoid facies and effusive volcanics) strongly affected by extensive mining contain little groundwater. Groundwater circulation in both crystalline and Paleozoic rocks is bound to the near-surface zone (mostly of 20 - 30 m thickness), where fissures and joints are widened by weathering and gravitational loosening of rock masses.

The Flysch Belt and the Klippen Belt stretch along the outer edge of the West Carpathians (area: 8 000 km^2). The former extends deep into the Inner West Carpathians (area: 3 800 km^2). They consist largely of rhythmically alternating Cretaceous and Palaeogene sandstones and claystones of flysch lithofaces. Groundwater circulation here is bound to tectonic weathering fissures up to 50 m deep. Extensive dislocations along which artesian mineral waters ascend from a deep substratum control deeper groundwater circulation. Groundwater is generally extremely sparse here.

Apart from Quaternary sediments, Middle and Upper Triassic limestone-dolomite complexes (area of 3 800 km^2) contain the most important groundwater resources in Slovakia. They hold Slovakia's biggest groundwater reserves. Jurassic and Cretaceous sediments (2 500 km^2) are unsuitable for groundwater accumulations because of their lithology (shales, sandstones, marl limestone etc.). Other limestone-dolomite complexes plunge to substantial depths below younger sediments and create conditions for deep groundwater circulation. Some groundwater is discharged through barrier springs at the contact with younger impermeable rocks while others are thermal and mineral waters in adjacent intramontaneous depressions. Discharges from springs range from several l.s^{-1} to 7000 l.s^{-1}. Surface streams drain a considerable percentage of waters from the limestone-dolomite complexes. Average groundwater discharge from Triassic carbonate complexes varies from 8 up to 17 l.s^{-1}. km^{-2}.

Neogene volcanics in central and eastern Slovakia (area of 5 160 km^2) have different hydrogeological settings. The rocks include andesite, rhyolite, basalt and related volcanoclastics. They have fissure-intergranular permeability. Springs in these rocks often discharge between 1 and 2 l.s^{-1}. Boreholes in the volcanics discharge 1 - 5 l.s^{-1}, in porous pyroclastics, exceptionally 10 - 15 l.s^{-1}. Boreholes at major fault lines rarely yield as much as 30 - 50 l.s^{-1}. The volcanics are locally underlain by Mesozoic carbonates with thermal and mineral waters which reach the surface along faults.

Figure 1: Main aquifers



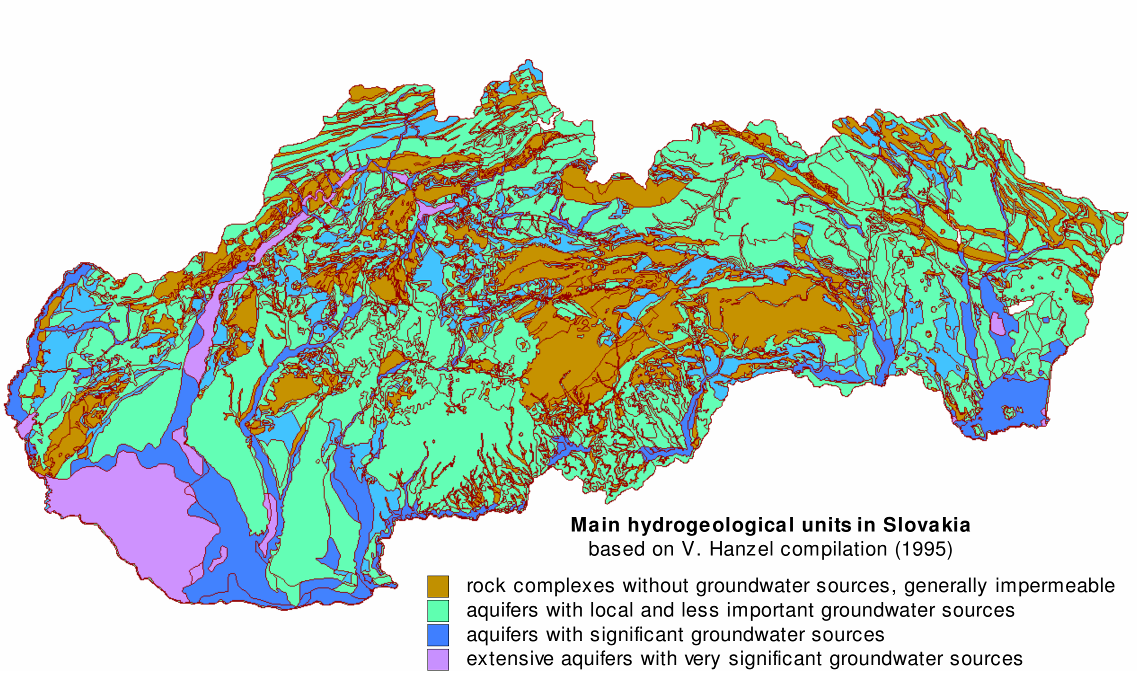


Figure 2 **Transmissivity distribution within main hydrogeological units in Slovakia.**

<u>Neogene</u> tectonic depressions (with the aerial extent of 9 000 km^2) are filled with impermeable clays alternating with sand and exceptionally also gravel layers in which artesian groundwater can accumulate. Artesian wells here yield about 1 - 3 l.s^{-1}, rarely 10 l.s^{-1}. Pliocene sediments as much as 2 500 – 3 000 m thick occur in the Danube Basin and contain rich reserves of thermal waters with total dissolved solids (TDS) up to 20 g.l^{-1} and temperatures up to 100 °C are also important for hydrogeologists.

From a hydrogeological point of view, the most significant <u>Quaternary</u> sediments in Slovakia are fluvial deposits laid down by the Danube and other large rivers. If their lithology is favourable, fluvial sediments enable considerable concentration of groundwater resources. Borehole discharges often exceed 30 - 50 l.s^{-1}. Major groundwater reserves are accumulated also in aeolian sediments, mainly in the Záhorie Lowland. They hold several groundwater bodies whose borehole discharges varying from 0.5 to 70 l.s^{-1}. Quaternary sediments at some places were considerably reshaped by neotectonic movements, which locally created thick accumulations of fluvial and glacial deposits, such as a 300 m thick depression filled with gravel and sand in the Danube Basin. Borehole discharges frequently reach 100 – 150 l.s^{-1}. The Danube Basin holds Slovakia's biggest groundwater dynamic resources counting as much as 22 000 l.s^{-1}. Glacial deposits are also very thick, particularly in and around the Vysoké Tatry Mts., where they exceed thickness of 400 m. Borehole discharges here range from 1.0 to 20 l.s^{-1}.

General description of groundwater quality
Fairly variegated (vertically as well as horizontally) variable lithofacies result in highly variable groundwater chemistries also within the complexes. T.D.S. values in groundwater in some crystalline massifs are as low as about 100 $mg.l^{-1}$. They are clearly controlled by altitude and consequently by the speed and length of groundwater circulation. In the summit sectors of the highest mountain ranges such as Tatry Mts. and Nízke Tatry Mts., T.D.S. is commonly of about 30 $mg.l^{-1}$, locally even less, but in lower mountains whose altitudes do not exceed 1000 m a.s.l. (Malé Karpaty Mts.) it reaches as much as 200 $mg.l^{-1}$. In general, T.D.S. values in groundwater of crystalline schists are by 10% higher than those in granitoids. This can be explained by the morphological position of both rock types as granitoids largely underlie summit parts of mountain ranges.

As far as general characteristics are concerned, COD_{Mn} mean values range from 1.0 $mg.l^{-1}$ to 1.5 $mg.l^{-1}$, thus suggesting a fairly low contamination degree of groundwater. Aggressive CO_2 content ranges between 13 $mg.l^{-1}$ and 23 $mg.l^{-1}$. Because of their low T.D.S., groundwater in the crystalline massifs is referred to as so-called "hungry" or "aggressive water". Concentrations of major elements are extremely low. Cations are dominated by Ca and Mg, whereas main anions include HCO_3, SO_4, Cl and NO_3. Major sources of macro pollutants (N forms, Cl and SO_4) comprise atmospheric deposition and local tourist and agricultural activities. Trace-element concentrations in groundwater are characterized by the following regularities:
a. Zn, Cr and Al concentrations are higher in crystalline schists;
b. concentrations of the other trace elements in granitoid rocks roughly equal those in crystalline schists.

The highest concentrations of virtually all trace elements in groundwater of the West Carpathian crystalline massifs occur in the vicinity of ore occurrences.
Variegated lithology in Paleozoic hydrogeologic units gave rise to extremely variegated and diverse groundwater chemistry. It consists virtually of all basic chemical and genetic types of groundwater. T.D.S. values in groundwater of the Paleozoic mostly range from 100 to 200 $mg.l^{-1}$ and increase from metamorphosed rocks through volcanics to sediments. The most widely distributed chemical type is Ca-Mg-HCO_3. Ca-Mg-HCO_3-SO_4 and Ca-Mg-SO_4 types occur only near major gypsum and anhydrite occurrences or sulphide mineralization. T.D.S. of these waters is usually several times the normal one, sometimes even over 1000 $mg.l^{-1}$ especially when the water contacts evaporites.

Mean concentrations of aggressive CO2 are 13 - 28 $mg.l^{-1}$ and COD_{Mn} oscillates closely around 2 $mg.l^{-1}$. Major components in Paleozoic groundwater comprise Ca, Mg and Sr as well as anions HCO_3, SO_4, NO_3 and Cl, whose increased concentrations are related to human activities (maximum NO_3 concentrations are approximately of about 35 $mg.l^{-1}$). As regards minor elements, mean contents of Fe and Mn are around 0.05 and 0.03 $mg.l^{-1}$ respectively, local peaks being located largely near ore occurrences. Trace-element concentrations are usually monotonous, e.g. average concentrations of aluminium are around 0.17 $mg.l^{-1}$ and those of zinc between 0.04 and 0.06 $mg.l^{-1}$.

In the Mesozoic, T.D.S. varies mostly from 300 mg.l^{-1} to 500 mg.l^{-1}. No major differences between waters from limestone, dolomites and mixes limestone-dolomite circulations have been distinguished. They differ only in their Mg/Ca coefficients (in eq. %) which are below 0.25 in groundwater from limestone (even below 0.1 in pure, notably organogenic limestone) and above 0.75 in groundwater circulating in dolomites. The lowest T.D.S. values in the Mesozoic (often below 50 mg.l^{-1}) occur in sandstone-quartzite-conglomerate formations. Average COD_{Mn} values amount to 1.9 - 2.4 mg.l^{-1}. Aggressive CO_2 concentrations are negligible or zero, owing to the huge presence of carbonates. Throughout the Mesozoic, cations are dominated by Ca and Mg, and anions by HCO_3 and SO_4. Because of the vulnerable environment, nitrate concentrations attain sometimes as much as 39 mg.l^{-1} and NH_4 sometimes over 1 mg.l^{-1}. Groundwater here typically contains little silica (about 10 mg.l^{-1}) and average concentrations of trace elements are a mere thousandths or hundredths of mg.l^{-1}. Barium contents are fairly high, their mean values being 0.03 - 0.08 mg.l^{-1}.

Groundwater chemistry in the Flysch Belt depends on the presence of individual lithofacies, i.e. share of claystones and sandstones in a given aquifer. The lowest T.D.S. values (366 mg.l^{-1}) are characteristic of sandstone facies. On the other hand, maximum T.D.S. values (up to 2000 mg.l^{-1}) are bound to aerial or local sources of contamination. COD_{Mn} values vary from 1.8 to 5.6 with respect to human-related impacts. The vast majority of groundwater is devoid of aggressive CO_2. In addition to Ca and Mg, major components include also Na. Anions are dominated by HCO_3, but sulphates are equally abundant in the vicinity of sulphide occurrences. High chloride contents (as much as 120 mg.l^{-1}) are of geogenic origin as they come from deeper groundwater dispersed in the first aquifer. Widely distributed in the Flysch Belt, anoxic environments gave rise to increased concentrations of minor elements, notably iron and manganese, sometimes even hydrogen sulphide (H_2S). Zinc is the most abundant trace element; concentrations of the others are as little as thousandths or ten thousandths of mg.l^{-1}.

Groundwater in the Klippen Belt area has T.D.S. between 220 mg.l^{-1} and 1200 mg.l^{-1}. It is controlled mainly by the percentage of carbonate and sandy-clayey-carbonate lithofacies. COD_{Mn} values vary around 2 mg.l^{-1}, locally around man-made sources up to 14 mg.l^{-1}. The vast majority of groundwater is devoid of aggressive CO_2. Cations in this groundwater are vastly dominated by Ca and Mg, and anions by bicarbonates and sulphates. As regards components significant from a water-management point of view, nitrate concentrations attain up to 40 mg.l^{-1} and the maximum NH_4 content is 1.4 mg.l^{-1}. As to trace elements, aluminium concentrations are about 0.1 mg.l^{-1}, zinc 0.02 mg.l^{-1} and barium ones 0.1 mg.l^{-1}. Concentrations of the other trace elements amount to thousandths or hundredths of mg.l^{-1}.

Chemical composition of groundwater in the Inner Carpathian Palaeogene is similar to that in the Flysch Belt. The only substantial difference is only a higher percentage of man-made sources because the Palaeogene typically underlies fairly densely populated and industrialized intermountain depressions. T.D.S. of groundwater varies from 370 mg.l^{-1} to 560 mg.l^{-1}, locally exceeding 1000 mg.l^{-1}. The presence of man-made contamination sources is reflected by COD_{Mn} values which sometimes reach nearly 10 mg.l^{-1}. Contents of aggressive CO_2 are generally low due to carbonate cement in Palaeogene lithofacies. Major components are dominated by calcium and magnesium. Bicarbonates and sulphates are the most plentiful anions in groundwater. Sodium contents are locally increased, notably in the Flysch lithofacies of the Palaeogene.

Average contents of nitrates vary around 9 mg.l^{-1}; locally reach up to 40 mg.l^{-1}. Aluminium and zinc are the most abundant trace elements.

Groundwater in Neogene sediments has T.D.S. between 130 and 2700 mg.l^{-1}. Such big differences are caused by diverse lithofacies of Neogene sediments. Low values typically occur in clayey-gravely lithofacies, medium in basal Neogene sediments and high near man-made sources of local or aerial importance. Associated COD_{Mn} values range from 1 to 38 mg.l^{-1}. Groundwater here is slightly aggressive. Major components are dominated by Ca, Mg and Na. HCO_3 and SO_4 are the most abundant anions in these groundwater. Another significant geogenic component is chloride content. Nitrate concentrations in groundwater unaffected by human activity vary around 10 mg.l^{-1}, but in contaminated groundwater, particularly in sandy-clayey-gravely lithofacies, the concentrations are enormously high as median is 93.3 mg.l^{-1} and maximum content as much as 862.7 mg.l^{-1}. Contents of minor elements are controlled by groundwater contamination. Concentrations of trace elements in groundwater polluted by human activity are several times higher than in unaffected ones.

Groundwater in Neogene volcanic formations has T.D.S. between 60 and 1900 mg.l^{-1}. Interestingly, the highest concentrations are found in mineralized areas and not in groundwater affected by human activity. COD_{Mn} values are 2 - 5 mg.l^{-1}. Contents of aggressive CO_2 are increased, their mean values ranging from 5 to 16 mg.l^{-1}. Ca and Mg are predominant major cations, sodium contents are increased locally. Anions consist mostly of bicarbonates, but sulphates are also widespread, notably in groundwater associated with effusive volcanics. Groundwater bound to Neogene volcanic are typically rich in silica whose mean contents are around 50 mg.l^{-1} except in mineralized effusives. As to trace elements, aluminium contents up to 58 mg.l^{-1} are noteworthy. Ore occurrences gave rise to local anomalies of trace elements.

Chemical composition of groundwater in Quaternary sediments is the most variable in space and is most affected by human activities from all aforementioned hydrogeological units. Average T.D.S. values range widely from 50 - 112 mg.l^{-1} in glacial and glaciofluvial sediments to 600 - 1000 mg.l^{-1} in fluvial sediments of flood planes and lowland sediments hydraulically connected with surface streams. Quaternary deposits recharged mostly by meteoric precipitation have T.D.S. around 235 mg.l^{-1}. In general, we may conclude that groundwater of the first aquifer or aeration zone in Quaternary sediments are contaminated. In addition to other evidence, this is suggested also by some group indices, such as COD_{Mn} up to 40 mg.l^{-1} and slightly alkaline pH. Least polluted are glacial and glaciofluvial sediments mainly in mountain areas devoid of man-made sources of contamination. Cations are dominated by Ca, Mg, and often also by Na mostly in so-called fluviogenic waters (groundwater directly hydraulically connected with a surface stream). Bicarbonates are the most widespread anions, but sulphates, chlorides and nitrates are widespread as well, in highly contaminated waters they even affect the water type. As regards minor components, iron and manganese concentrations in anoxic environments exceed 1 mg.l^{-1}. Higher concentrations of aggressive CO_2 are typical of groundwater in glacial and glaciofluvial sediments. Trace-element concentrations in groundwater of Quaternary deposits are largely of man-made origin. The lowest average concentrations of trace elements occur in groundwater of glacial and glaciofluvial sediments. Aluminium and zinc have the highest contents.

(inter-)connectivity and the possible trans-boundary extent of the major aquifers in Slovakia
Four types of major aquifer were defined on the Slovak territory:

1. important Quaternary aquifers;
2. important Neogene aquifers;
3. important Palaeogene aquifers;
4. important karstic aquifers, mainly of Middle and Upper Triassic age, belonging to several structural and tectonic units.

Quaternary aquifers are entirely interconnected throughout one alluvial fan of the main rivers and its tributary alluvia. This is also expressed on the Quaternary groundwater body's delineation.

The interconnectivity of Neogene, Palaeogene and karstic Mesozoic aquifers was distinguished when first hydrogeological rayons and partial hydrogeological rayons were delineated in 1974. Therefore, existing connections and mutual separations were applied in this delineation.
Recently, when groundwater bodies are established by using the hydrogeological rayons, subrayons and partial hydrogeological rayons as the base or "the background mosaic", the interconnections and separations are projected also into the groundwater bodies delineation. Nevertheless, some transboundary major aquifers can be distinguished on the Slovak territory.

There are 5 neighbouring countries (Austria, Czech Republic, Poland, Ukraine and Hungary):

Austria:
The whole boundary is formed by the river Morava/March. Therefore, its alluvial fan can be considered as a transboundary aquifer. Furthermore, parallel to the Malé Karpaty Mts., a huge Quaternary graben, 4 – 8 km wide, filled with 40 – 80 m thick gravely material and eolian sands is developed in the Slovak part of the Vienna Basin. It's extremely permeable material forms the so-called Zohor – Marchegg hydrogeological structure, that continues also in the Austrian part of the Vienna Basin, is another transboundary aquifer. Both Morava/March alluvial sediments and Zohor – Marchegg hydrogeological structure are included within the SK1000100P groundwater body in the "Quaternary layer" of groundwater bodies, named as "Intergranular groundwater body of the Vienna Basin Quaternary sediments in the Danube watershed area".

Czech Republic:
Morava river springs in the Czech Republic and it approaches Slovak territory in the region of Skalica and Holíč. Alluvial fan of the river is a regionally important aquifer, and can be considered as transboundary aquifer shared with Czech Republic. This aquifer is on the Slovak side also included within the SK1000100P groundwater body "Intergranular groundwater body of the Vienna Basin Quaternary sediments in the Danube watershed area" in the "Quaternary layer".
The border with Czech Republic the follows the mountain range of Biele / Bílé Karpaty Mts., Javorníky Mts., and Moravskoslezské Beskydy Mts., all formed by low permeable flysh units. Therefore, no other major aquifer in the Slovak territory can be considered as transboundary aquifer shared with Czech Republic.

Poland:
The border with Poland also the follows the flysh mountain ranges of Beskydy / Besciady Mts., both on the west and on the east, with only local aquifer present. However, in the centre in the outstanding region of Tatry Mts., several transboundary aquifers appear, built by Middle and Upper Triassic karstic aquifers, belonging to several structural and tectonic units. On the Slovak territory, they belong to the “Pre-Quaternary layer” of the groundwater bodies, to the groundwater body SK200270KF “Dominant karst-fissure groundwater body of the Veľká Fatra, Chočské vrchy and Západné Tatry Mts. in the watershed area of Váh” on the west and SK200440KF “Dominant karst-fissure groundwater body of the Tatry Mts. in the watershed area of Poprad and Dunajec” on the east.

Ukraine:
The north of the common border is formed by folded and unfolded Palaeogene flysh sediments (low permeability), towards to the south some Neovolcanic mountains with aquifers of local importance and the southern part is formed by Quaternary sediments of the Tisa river and its tributaries. These can be considered as a transboundary aquifer – on the Slovak side they are included within the “Quaternary layer” of groundwater bodies, named as “Intergranular groundwater body of Quaternary sediments of the S part of Bodrog watershed area” and numbered with SK1001500P.

Hungary:
The majority of Slovak transboundary aquifers is shared with Hungary. On the east, the same Quaternary sediments of the Tisa / Tisza and Bodrog rivers and their tributaries are developed, considered as a transboundary aquifer – on the Slovak side there is groundwater SK1001500P (the same as in the case of Ukraine), included within the “Quaternary layer” of groundwater bodies, named as “Intergranular groundwater body of Quaternary sediments of the S part of Bodrog watershed area”. West from the city of Košice (or north from the Hungarian city of Miskolc), a huge Mesozoic karstic aquifer outcrops on both sides of the border, thus forming the National park of Aggtelek in Hungary or the Slovenský Kras National Park in Slovakia, both included in the UNESCO World Heritage. The pre-Quaternary groundwater body, marked as SK200480KF (Dominant karst-fissure groundwater body of the Slovenský Kras Mts. in the watershed area of Hron and Hornád) is distinguished on the Slovak territory.
Alluvial groundwater in Quaternary sediments of Slaná / Sajó and Rimava rivers enter the Hungarian territory near the city of Ózd (Hungary) unified as one river Sajó alluvia. This transboundary aquifer are marked as SK1001100P and SK1000900P, named as “Intergranular groundwater body of Quaternary sediments of the Slaná river and its tributaries in the Hron watershed area” and “Intergranular groundwater body of Quaternary sediments of the Rimava river and its tributaries in the Hron watershed area”.

A long part of the common border with Hungary is formed by the Ipeľ / Ipoly river. Groundwater present in its Quaternary alluvial sediments is shared by both countries and alluvial fan can be considered as transboundary aquifer. The respective groundwater body SK1000800P belongs to the Quaternary “layer” in Slovakia (“Intergranular groundwater body of Quaternary sediments of the Ipeľ river in the Hron watershed area”).

Interesting situation is on this part of the Slovak / Hungarian border, formed by the Danube river between the cities of Štúrovo / Esztergom and Komárno / Komárom. The huge Mesozoic karstic aquifer is recharged only on the Hungarian territory in the Pilis Mts., but discharged by both fresh groundwater springs and geothermal springs and wells on the Hungarian territory and purely geothermal springs and wells on the Slovak territory. This shared aquifer is marked as GWB SK 3-1/M (Geothermal groundwater body of the Komárno high block) and GWB SK 3-2/M (Geothermal groundwater body of the Komárno marginal block). Potential transboundary problem arises from mine dewatering of brown coal mines in the region of Dorog – Tatabánya (Pilis Mts.) on the Hungarian site. Extensive depression cone and overall decrease of groundwater table in this area (sometimes even several hundreds of meters), causes also decrease of piezometric levels of geothermal waters used for recreation purposes in Patince – Virt area. Although not so intensive as in the XX^{th} century eighties, the losses of hydraulic pressure in the cold karstic aquifer in the south influence the geothermal aquifer on the north, divided by the state boundary created by the river of Danube.

The Quaternary sediments of the Danube river between the cities of Bratislava / Poszony and Komárno / Komárom form a huge accumulation, sometimes of 500 m thickness, near Gabčíkovo. This shared transboundary aquifer is marked as SK1000200P (Intergranular groundwater body of Quaternary sediments in the W part of the Danubian Basin in the Danube watershed area) and SK1000300P (Intergranular groundwater body of Quaternary sediments of the Danubian Basin in the Váh watershed area), because respective Quaternary groundwater body is administratively cut by the water divide of the Danube and Váh rivers.

Figure 3 Transboundary aquifers

River Basins

There are 6 river basins:

Bodrog, including Tisa

Dunaj

Vßh

Hron

Hornßd

Poprad a Dunajec

The map is shown below:

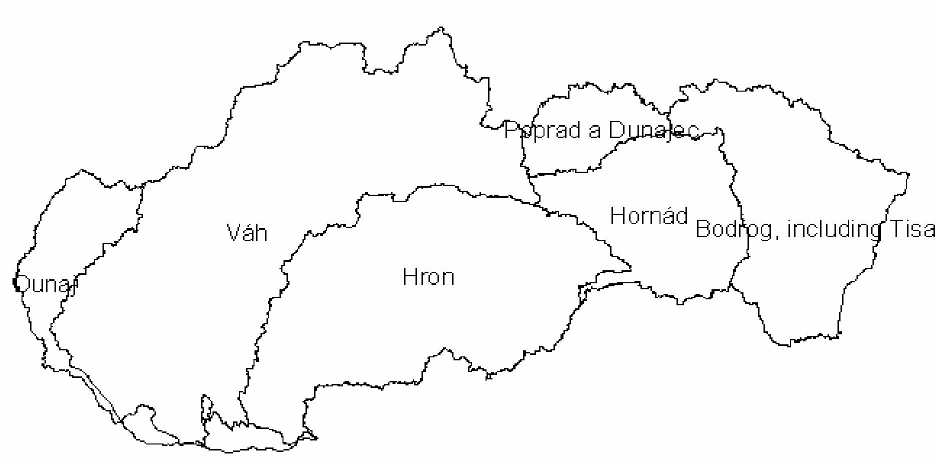


Figure 5: Main river basins in Slovakia

Sub activity 1.1.2 Groundwater system analyses

Result 1: Contours of the groundwater flow systems identified on a regional scale
Groundwater balancing in Slovakia. GIS maps with contours of the groundwater flow systems identified on a regional scale (based upon available groundwater quantity and quality data) were not identified since it was decided for the delineation of groundwater bodies the hydrogeological rayons, subrayons and partial hydrogeological rayons are used as the base or “the background mosaic” instead of a groundwater system analysis, the interconnections and separations are projected also into the groundwater bodies delineation. The results, that is the description of rayons is given in chapter 3.1

Result 2: Recharge/infiltration areas and seepage/discharge areas (i.e. abstraction wells and rivers)
No information is available on seepage and discharge areas within Slovakia. The seepage/discharge from rivers will be delivered by the work group Surface Water.

A GIS map was compiled for the groundwater abstraction (see below).

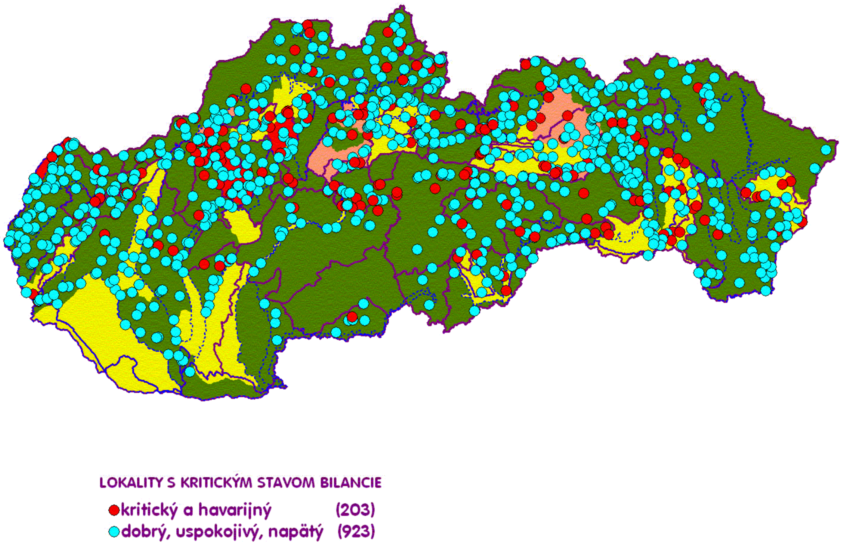


Figure 6: groundwater abstraction sites

Sub activity 1.1.3 Identification and grouping of groundwater bodies

Result 1: Delineated groundwater bodies

De steps which lead to groundwater bodies are illustrated through a series of maps shown below. The final step, the delineated groundwater bodies for each of the three layers is discussed separately.

Pre-Quaternary groundwater bodies

Together, 59 groundwater bodies were delineated in the Pre-Quaternary layer of groundwater bodies in Slovakia. Pre-Quaternary groundwater bodies (codes, names, delineation) in WGS 84 projection are delineated in the Earth_GWB_preQuaternary files of the related GIS. As they were created by combination of neighbouring hydrogeological rayons, sub-rayons and partial hydrogeological rayons of similar permeability types, history of groundwater abstraction balance within each groundwater body can be followed back to some decades. On the other hand, each groundwater body can be better evaluated by using long term time series and monitored data on its groundwater status. The way of generating Pre-Quaternary groundwater bodies from hydrogeological rayons, sub-rayons and partial hydrogeological rayons is depicted in Table 1.

Figure 7: Pre-Quaternary groundwater bodies

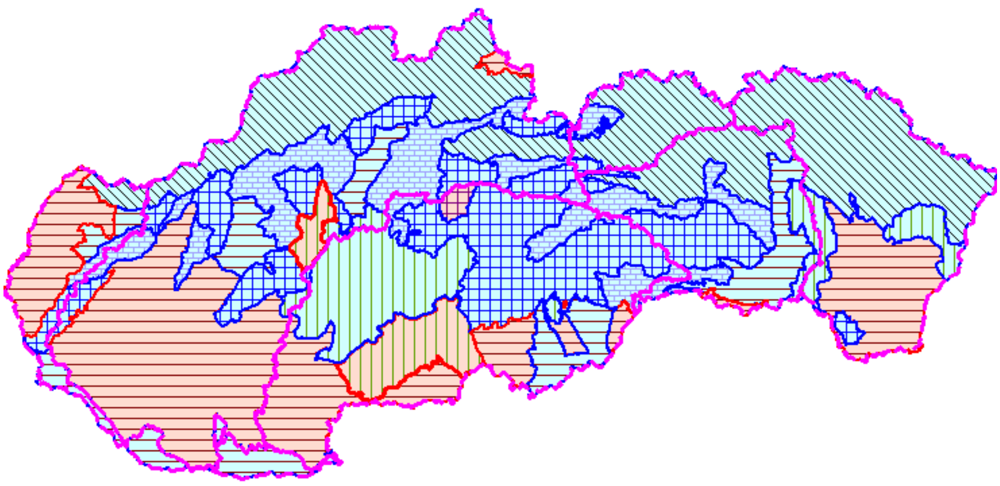


Table 1: Generation of Pre-Quaternary groundwater bodies from hydrogeological rayons, sub-rayons and partial hydrogeological rayons report in Slovak Republic.

code	groundwater body name	area [km^2]	generating of the groundwater body by combining of ...
SK200010FK	Fissure and karst-fissure groundwater body of the Pezinské Karpaty Mts. in the watershed area of Dunaj	179,059	partial rayons MA 10; MA 20 a MA 30 of the rayon MG 008 + partial rayon DN 20 of the rayon MG 055
SK2000200P	Intergranular groundwater body of the Vienna Basin in the watershed area of Dunaj	1 484,726	the whole rayon Q 001; N 002; Q 004; NQ 005; QN 007 + bigger (W) part of the rayon Q 003
SK200030FK	Fissure and karst-fissure groundwater body of the Pezinské Karpaty Mts. in the watershed area of Váh	222,033	sub-rayon VH 10 of the rayon MG 008 + partial rayons VH 10 a VH 20 of the rayon MG 055
SK2000400P	Intergranular groundwater body of the W part of the Vienna Basin in the watershed area of Dunaj	260,924	the whole rayon QN 006 + sub-rayon MA 00 of the rayon NM 044 + smaller (E) part of the rayon Q 003
SK2000500P	Intergranular groundwater body of the Pannonian Basin in the watershed area of Dunaj	1 043,038	the whole rayon Q 056 + sub-rayon DN 00 of the rayon Q 051 + sub-rayon DN 00 of the rayon Q 052 + southernmost part of the partial rayon VH 30 v rajóne MG 055 + sub-rayon DN 00 of the rayon Q 057 + sub-rayon DN 30 of the rayon N 058 + sub-rayon DN 00 of the rayon Q 074 + sub-rayons DN 00 a IL 00 of the rayon V 096
SK200060KF	Dominant karst-fissure groundwater body of the Pezinské Karpaty Mts. in the watershed area of Dunaj	139,149	sub-rayon of the Morava river with partial rayons MA 10, MA 20, MA 30 of the rayon MN 053 + sub-rayon MA 00 of the rayon M 054
SK2000700F	Fissure groundwater body in the W part of the flysh belt in the watershed area of Dunaj	253,848	the whole rayon PM 043
SK200080KF	Dominant karst-fissure groundwater body of Pezinské, Brezovské and ?achtické Karpaty Mts. in the watershed area of Váh	311,854	the whole rayon M 045 + sub-rayon of the Váh river with partial rayons VH 10, VH 20, VH 30 of the rayon MN 053 + sub-rayon VH 00 of the rayon M 054
SK200090FK	Fissure groundwater body of the Myjavská pahorkatia hills in the watershed area of Váh	127.100	only sub-rayon VH 00 of the rayon NM 044
SK2001000P	Intergranular groundwater body of the Pannonian Basin and its folders in the watershed area of Váh	6 248,370	the whole rayon Q 048; Q 049; Q 050; Q 072; NQ 073 + sub-rayon VH 00 of the rayon Q 051 + sub-rayon VH 00 of the rayon Q 052 + bigger part of the sub-rayon VH 30 of the rayon MG 055 + sub-rayon VH 00 of the rayon Q 057 + sub-rayon of the Nitra river with partial rayons NA 10; NA 20; NA 30 of the rayon N 058 + partial rayon VH 30 of the rayon N 058 + sub-rayons NA 00; VH 00 of the rayon Q 074 + southern parts of the sub-rayons NA 10; NA 20; NA 31 + the whole sub-rayon VH 20 of the rayon NQ 071 + southern parts of the partial rayons NA 10; NA 20; NA 31 in the sub-rayon of the Nitra river of the rayon NQ 071 up to the water divide of Radošinka / Bojnianka streams

code	groundwater body name	area [km²]	generating of the groundwater body by combining of ...
SK200110KF	Dominant karst-fissure groundwater body of Považský Inovec Mts. in the watershed area of Váh	193,635	the whole rayon MG 047
SK200120FK	Fissure and karst-fissure groundwater body of the Považský Inovec Mts. in the watershed area of Váh	402,083	the whole rayon QM 038; MG 046; GM 068
SK2001300P	Intergranular groundwater body of the Bánovce Basin and its folders in the watershed area of Váh	548,077	northern parts of the partial rayons NA 10; NA 20; NA 31 of the Nitra river sub-rayon of the rayon NQ 071 up to the water divide of Radošinka / Bojnianka streams
SK200140KF	Dominant karst-fissure groundwater body of the Strážovské vrchy and Lúčanská Malá Fatra Mts. in the watershed area of Váh	1 125,987	the whole rayons M 032; M 035; M 036; M 064; M 066
SK200150FP	Fissure and karst-fissure groundwater body od the Tribeč Mts.	579,286	the whole rayons MG 070; MG 069 + partial rayon NA 32 of the rayon NQ 071
SK200160FK	Fissure and karst-fissure groundwater body of the Strážovské vrchy Mts. in the watershed area of Váh	278,948	the whole rayon PG 065
SK200170FP	Fissure and intergranular groundwater body of the Horná Nitra Basin neovolcanoes and Tertiary sediments in the watershed area of Váh	335,526	the whole rayon QN 067 + partial rayon NA 20 of the rayon V 086
SK2001800F	Fissure groundwater body of the W part of flysch belt and podtatranská skupina group in the watershed area of Váh	4 451,705	the whole rayon PQ 018; MP 026; PQ 028; QP 029; MP 034; QN 37; Q 039; PM 040; PM 041; PM 042 + partial rayon VH 20 of the rayon M 015 + partial rayon VH 10 of the rayon PN 025
SK200190FK	Fissure and karst-fissure groundwater body of the Žiar Mts. in the watershed area of Váh	77,874	the whole rayon PQ 063
SK200200FP	Fissure and intergranular groundwater body of the Vtáčnik and Kremnické vrchy Mts. neovolcanoes in the watershed area of Váh	179,099	partial rayons NA 30 a VH 40 of the rayon V 082 + partial rayon NA 10 of the rayon V 086
SK2002100P	Intergranular groundwater body of the Turčianska kotlina Basin in the watershed area of Váh	438,588	the whole rayon QP 033
SK200220FP	Fissure and intergranular groundwater body of the N part of Central Slovakian Neovolcanoes	2 676,943	the whole rayon Q 080; NQ 081; V 083; NV 084; N 087; V 088; V 093; + Hron river sub-rayon with partial rayons HN 10; HN 20; HN 30 in the rayon V 082 + Hron river sub-rayon with partial rayons HN 10; HN 20; HN 30 of the rayon V 086 + partial rayon NA 30 of the rayon V 086

code	groundwater body name	area [km²]	generating of the groundwater body by combining of ...
SK2002300P	Intergranular groundwater body of the Pannonian Basin and Ipeľská kotlina Basin in the watershed area of Hron	2 000,440	the whole rayon QN 059; Q 060; N 061; N 062; NQ 095 + sub-rayon HN 00 of the rayon Q 057 + Hron river sub-rayon with partial rayons HN 20; HN 30; HN 40 of the rayon N 058 + sub-rayon HN 00 of the rayon V 096 + W part of the rayon Q 091 up to the Strháre-Trenč depression
SK200240FK	Fissure and karst-fissure groundwater body of the Malá Fatra Mts. in the watershed area of Váh	406,534	the whole rayon MG 027; MG 030; MG 031
SK200250KF	Dominant karst-fissure groundwater body of the Veľká Fatra Mts. in the watershed area of Hron	168,292	the whole rayon MP 079 + sub-rayon HN 00 of the rayon M 023 + Hron river sub-rayon with partial rayons HN 10; HN 40; HN 50 in the rayon M 024
SK200260FP	Fissure and intergranular groundwater body of the S part of Central Slovakian Neovolcanoes in the watershed area of Hron	1 439,633	the whole rayon V 094 + part of the rayon Q 091 up to the state boundary along the Strháre-Trenč depression
SK200270KF	Dominant karst-fissure groundwater body of the Veľká Fatra, Chočské vrchy and Západné Tatry Mts. in the watershed area of Váh	1 006,513	the whole rayon MG 014; M 019; M 020; G 021; M 022; + partial rayon VH 10 of the rayon M 015 + sub-rayon VH 00 of the rayon M 023 + Váh river sub-rayon with partial rayons VH 10; VH 20; VH 31; VH 32; VH 40 of the rayon M 024
SK200280FK	Fissure and karst-fissure groundwater body of the Nízke Tatry and Slovenské Rudohorie Mts. in the watershed area of Hron	3 508,818	the whole rayon QG 075MG 077; MG 078; G 085; GN 089; G 127; G 128; M 130 + partial rayons HN 11; HN 12; HN 14 of the rayon MG 076 + W part of the partial rayon HN 20 of the rayon MG 076
SK200290FK	Fissure and karst-fissure groundwater body of the S part of Nízke Tatry Mts. in the watershed area of Hron	170,562	partial rayons HN 13 a HN 15 + E part of the partial rayon HN 20 of the rayon MG 076
SK200300FK	Fissure and karst-fissure groundwater body of the NW of Nízke Tatry Mts. in the watershed area of Váh	295,367	the whole rayon MG 017
SK2003100P	Intergranular groundwater body of the Lučenská kotlina Basin and W part of Cerová vrchovina hills in the watershed area	564,501	the whole rayons NQ 090; NV 092 + easternmost part of the rayon Q 091 over the Strháre-Trenč depression
SK2003200P	Intergranular groundwater body of the Oravská kotlina Basin in the watershed area of Váh	118,909	partial rayon VH 20 of the rayon PN 025
SK2003300F	Fissure groundwater body of the podtatranská skupina group in the Liptovská kotlina Basin in the watershed area of Váh	586,610	the whole rayon QP 016 + partial rayon VH 10 of the rayon QG 009

code	groundwater body name	area [km²]	generating of the groundwater body by combining of ...
SK200340KF	Dominant karst-fissure groundwater body of the NE of Nízke Tatry Mts. in the watershed area of Váh	229,149	the whole rayon M 010
SK200350FK	Fissure and karst-fissure groundwater body of the Tatry Mts. in the watershed area of Váh	216,813	partial rayons VH 20 a VH 30 of the rayon QG 009
SK200360FK	Fissure and karst-fissure groundwater body of the NE of Nízke Tatry Mts. in the watershed area of Váh	278,229	the whole rayons MG 011 + MG 012
SK2003700P	Intergranular groundwater body of the Rimavská kotlina Basin, Oždianska pahorkatina hills and E part of Cerová vrchovina hills of the watershed area of Hron	810,986	the whole rayon Q 132; NV 133; NV 135; N 136
SK200380FP	Fissure and intergranular groundwater body of the neovolcanoes of Pokoradzská tabuľa Plateau	61,054	partial rayon SA 10 of the rayon NV 134
SK200390KF	Dominant karst-fissure groundwater body of the Muránska Planina Plateau in the watershed area of Hron	330,507	the whole rayon M 126 + Slaná river sub-rayon with partial rayons SA 20 a SA 50 of the rayon MG 116
SK2004000P	Intergranular groundwater body of the Valická pahorkatina hills in the watershed area of Hron	163,831	partial rayon SA 20 of the rayon NV 134
SK200410KF	Fissure and karst-fissure groundwater body of the E of Nízke Tatry Mts. in the watershed area of Váh	80,493	Váh river sub-rayon with partial rayons VH 10 a VH 20 of the rayon MG 013
SK200420FK	Fissure and karst-fissure groundwater body of the Kozie chrbty Mts. in the watershed area of Poprad and Dunajec	72,418	the whole rayon M 140
SK200430FK	Fissure groundwater body of the Nízke Tatry and Kozie chrbty Mts. in the watershed area of Hornád	109,815	only partial rayon HD 20 of the rayon PQ 115
SK200440KF	Dominant karst-fissure groundwater body of the Tatry Mts. in the watershed area of Poprad and Dunajec	191,239	the whole rayon MG 142 + partial rayon PD 20 of the rayon QG 139
SK2004500P	Intergranular groundwater body of the Gemerská pahorkatina hills in the watershed area of Hron	126,385	the whole rayon NM 131
SK200460KF	Dominant karst-fissure groundwater body of the Slovenský Raj and Galmus Mts. in the watershed area of Hornád	389,654	the whole rayon MG 117 + Hornád river sub-rayon with partial rayons HD 10; HD 20; HD 30 a HD 40 of the rayon MG 116 + sub-rayon HD 10 of the rayon MG 013

code	groundwater body name	area [km^2]	generating of the groundwater body by combining of ...
SK2004700F	Fissure groundwater body of the flysch belt and podtatranská skupina group in the watershed area of Poprad and Dunajec	1 707,204	the whole rayon PQ 141 + sub-rayon PD 00 of the rayon P 109 + sub-rayon PD 00 of the rayon PQ 115 + sub-rayon PD 00 of the rayon P 119 + partial rayon PD 10 of the rayon QG 139
SK200480KF	Dominant karst-fissure groundwater body of the Slovenský Kras Mts. in the watershed area of Hron and Hornád	598,079	partial rayons SA 10; SA 20; SA 30; SA 40 a SA 50 (without SA 60 !) of the rayon MQ 129
SK2004900F	Fissure groundwater body of the podtatranská skupina group and flysch belt in the watershed area of Hornád	1 648,160	the whole rayons QP 120 a P 122 + sub-rayon HD 00 of the rayon P 109 + partial rayon HD 10 of the rayon PQ 115 + partial rayon HD 20 of the rayon P 119
SK200500FK	Fissure and karst-fissure groundwater body of the Slovenské Rudohorie Mts. in the watershed area of Hornád	1 040,696	the whole rayons G 118 a G 137
SK200510KF	Dominant karst-fissure groundwater body of the Branisko and ?ierna Hora Mts. in the watershed area of Hornád	384,212	the whole rayons MG 121 a MG 124
SK2005200P	Intergranular groundwater body of the Abovská pahorkatina hills in the watershed area of Hornád	73,779	partial rayon SA 20 of the rayon NQ 138
SK2005300P	Intergranular groundwater body of the Košická kotlina Basin in the watershed area of Hornád	1 124,018	the whole rayon NQ 123; Q 125 + partial rayons HD 20; HD 50 of the rayon V 111 + partial rayon SA 60 of the rayon MQ 129 + partial rayons SA 10; SA 30 of the rayon NQ 138
SK200540FP	Fissure and intergranular groundwater body of the Slanské vrchy Mts. neovolcanoes in the watershed area of Hornád	310,556	partial rayon HD 10; HD 20 a HD 30 of the rayon VN 111
SK200550FP	Fissure and intergranular groundwater body of the Slanské vrchy Mts. neovolcanoes in the watershed area of Bodrog	344,029	Bodrog river sub-rayon with partial rayons BG 10; BG 20 a BG 30 in the rayon VN 111
SK200560FK	Fissure and karst-fissure groundwater body of the ""Zemplín island"" Mts. in the watershed area of Bodrog	98,970	the whole rayon NG 113
SK2005700F	Fissure groundwater body of the flysch belt and podtatranská skupina group in the watershed area of Bodrog	4 106,788	the whole rayon QPM 097; P 098; PQ 105; PQ 110 + partial rayon BG 30 of the rayon VNP 100 + sub-rayon BG 00 of the rayon PQ 109
SK2005800P	Intergranular groundwater body of the East Slovakian Basin in the watershed area of Bodrog	2 299,046	the whole rayon NQ 101; QN 102; QN 103; QN 104; QN 106; N 107; Q 108; N 112; Q 114 + partial rayon BG 20 of the rayon VNP 100
SK200590FP	Fissure and intergranular groundwater body of Vihorlat Mts. neovolcanoes in the watershed area of Bodrog	455,998	only the partial rayon BG 10 of the rayon VNP 100

Quaternary groundwater bodies
The uppermost layer is formed by Quaternary sediments, mostly river alluvia. Groundwater there is generally connected to surface water stream by its genesis, and there is continuous and strong hydraulic connection of the surface water and groundwater at least in the stream neighbourhood. Quaternary groundwater bodies were delineated by combining hydrogeological rayons, sub-rayons and partial rayons in the similar way as the previous layer, taking into account Quaternary geological age and genesis of sediments.

Together, 16 groundwater bodies were delineated in the Quaternary layer of groundwater bodies in Slovakia. Quaternary groundwater bodies (codes, names, delineation) in WGS 84 projection are delineated in the Earth_GWB_Quaternary files of the related GIS. The way of generating Quaternary groundwater bodies from hydrogeological rayons, sub-rayons and partial hydrogeological rayons is shown in Table 2.

Figure 8 Quaternary groundwater bodies

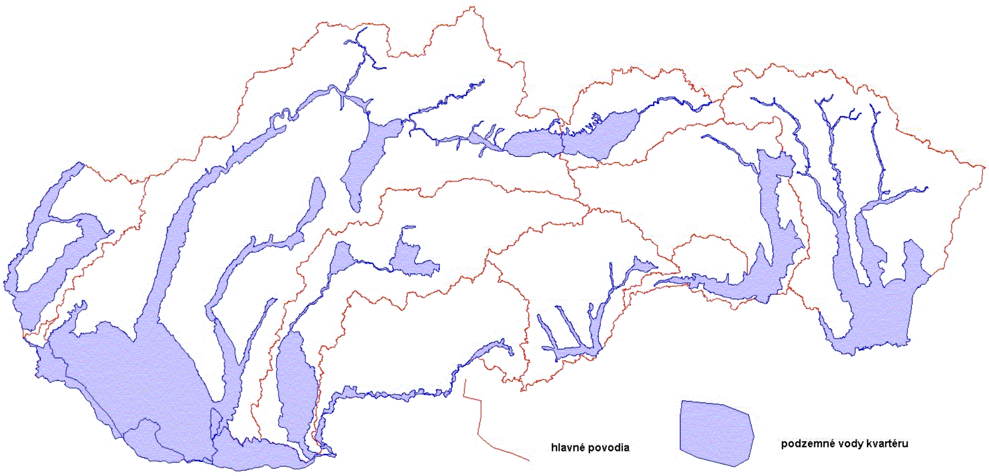


Table 2. Generation of Quaternary groundwater bodies from hydrogeological rayons, sub-rayons and partial hydrogeological rayons report in Slovak Republic.

code	groundwater body name	area [km^2]	generating of the groundwater body by combining of ...
SK1000100P	Intergranular groundwater body of the Vienna Basin Quaternary sediments in the Danube watershed area	518,749	the whole rayons Q 001; Q 003; Q 004; QN 006; QN 007
SK1000200P	Intergranular groundwater body of Quaternary sediments in the W part of the Danubian Basin in the Danube watershed area	518,749	sub-rayon DN 00 of the rayon Q 051 + sub-rayon DN 00 of the rayon Q 052 + S part of the partial rayon VH 30 in the rayon MG 055
SK1000300P	Intergranular groundwater body of Quaternary sediments of the Danubian Basin in the Váh watershed area	1 668,112	bigger (N) part of the partial rayon VH 30 in the rayon MG 055 + sub-rayon VH 00 of the rayon Q 051+ sub-rayon VH 00 of the rayon Q 052
SK1000400P	Intergranular groundwater body of Quaternary sediments of rivers Váh, Nitra and their tributaries in the S part of the Váh watershed area	1 943,020	the whole rayon Q 048 + sub-rayons NA 00; VH 00 of the rayon Q 074 + sub-rayon VH 10 a partial rayon NA 10 of the rayon Q 072+ partial rayon NA 10 of the rayon NQ 073 + partial rayons NA 10; NA 32 of the rayon NQ 071 + partial rayon NA 10 of the rayon QN 067 + sub-rayon VH 00 in the rayon Q 057
SK1000500P	Intergranular groundwater body of Quaternary sediments of the Váh river and its tributaries in the N part of the Váh watershed area	1 069,302	the whole rayon Q 039 + partial rayon VH 10 of the rayon PQ 028 + partial rayon VH 10 of the rayon QP 029 + partial rayons VH 10; VH 30 of the rayon QN 037 + partial rayons VH 10; VH 30 of the rayon QM 038 + connection of the alluvia in the area of the Púchov dam + partial rayons VH 10; VH 20; VH 30; VH 40; VH 51; VH 52; VH 53; VH 61; VH 62 a VH 63 of the rayon QP 33 + partial rayon VH 20 in the rayon PQ 018 + connection of the alluvia in the area of the Strečno narrowing + connection of the alluvia in the area of the Kraľovany narrowing + partial rayon VH 10 of the rayon QG 009 a partial rayons VH 11; VH 12; VH 13; VH 14; VH 15 a VH 17 of the rayon QP 016
SK1000600P	Intergranular groundwater body of Quaternary sediments in the E part of the Danubian Basin in the Danube watershed area	514.542	the whole rayon Q 056 + + sub-rayon DN 00 of the rayon Q 057 + sub-rayon DN 30 of the rayon N 058 + sub-rayon DN 00 of the rayon Q 074 + sub-rayon IL 00 in the rayon V 096
SK1000700P	Intergranular groundwater body of Quaternary sediments of the Hron river in the Hron watershed area	723,773	the whole rayons QN 059; Q 060; Q 080
SK1000800P	Intergranular groundwater body of Quaternary sediments of the Ipeľ river in the Hron watershed area	198,072	the whole rayon Q 091
SK1000900P	Intergranular groundwater body of Quaternary sediments of the Rimava river and its tributaries in the Hron watershed area	111,440	W part of the rayon Q 132 (in the Rimava basin up to Lenartovce)

code	groundwater body name	area [km2]	generating of the groundwater body by combining of ...
SK1001000P	Intergranular groundwater body of Quaternary sediments of the Poprad and Dunajec watershed area	420,759	partial rayon PD 10 of the rayon QG 139 + partial rayon PD 10 of the rayon PQ 141
SK1001100P	Intergranular groundwater body of Quaternary sediments of the Slaná river and its tributaries in the Hron watershed area	140,237	E part of the rayon Q 132 (in the Slaná basin up to Lenartovce) + partial rayon SA 20 of the rayon G 128 + partial rayon SA 30 of the rayon MQ 129
SK1001200P	Intergranular groundwater body of Quaternary sediments of the Hornád watershed area	934,295	partial rayons HD 20; HD 50 of the rayon VN 111 + partial rayon HD 10 of the rayon QP 120 + partial rayons HD 10; HD 20 of the rayon NQ 123 + partial rayons HD 10; HD 20 of the rayon Q 125 + partial rayon SA 60 of the rayon MQ 129 + partial rayon SA 10 of the rayon NQ 138 + connection of the Torysa alluvia in the area NW from Prešov
SK1001300P	Intergranular groundwater body of Quaternary sediments of the Topľa river in the Bodrog watershed area	35,941	partial rayon BG 10 of the rayon PQ 110
SK1001400P	Intergranular groundwater body of Quaternary sediments of the Ondava river in the Bodrog watershed area	34,427	partial rayon BG 10 of the rayon PQ 105
SK1001500P	Intergranular groundwater body of Quaternary sediments of the S part of Bodrog watershed area	1 470,868	the whole rayons QN 102; QN 103; QN 104; QN 106; QN 108; Q 114
SK1001600P	Intergranular groundwater body of Quaternary sediments of the Laborec river in the Bodrog watershed area	33,154	N part of the partial rayon BG 10 of the rayon QPM 097 up to the Cirocha tributary

Geothermal groundwater bodies

In whole, 101 groundwater bodies were delineated in three superimposed layers on the territory of Slovak Republic (49 030 km2). Geothermal groundwater bodies cover 17 515 km2, e.i. 39 % of the total area of the state, and the mean area of the geothermal groundwater body is 515 km2. The mean area of the Pre-Quaternary groundwater body is 832 km2 and this layer covers the whole country. Quaternary groundwater bodies cover 10 647 km2, e.i. 22 % of the total area of the state, and the mean area of the Quaternary groundwater body is 665 km2.

Figure 9: Geothermal groundwater bodies

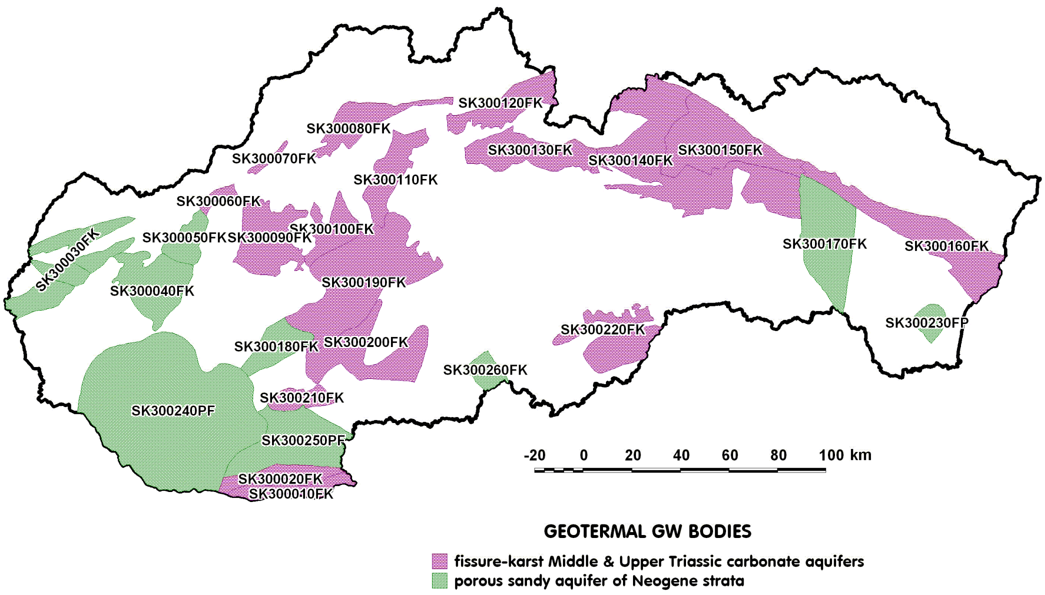


Table 3: Geothermal groundwater bodies

code	groundwater body name	area [km²]
SK300010FK	Geothermal waters of the Komárno high block structure	249.1
SK300020FK	Geothermal waters of the Komárno marginal block structure	312.5
SK300030FK	Geothermal waters of the Šaštín structure with adjacent NW and NE sunken belts	230.2
SK300030FK	Geothermal waters of the Lakšárska Nová Ves elevation structure	124.3
SK300030FK	Geothermal waters of the Závod-Studienka sunken belt structure	141.4
SK300030FK	Geothermal waters of the Láb-Malacky elevation with adjacent sunken blocks structure	239.8
SK300040FK	Geothermal waters of the Trnavský záliv Embayment structure	618.5
SK300050FK	Geothermal waters of the Piešťanský záliv Embayment structure	234.5
SK300060FK	Geothermal waters of the Trenčianska kotlina Basin structure	81.3
SK300070FK	Geothermal waters of the Ilavská kotlina Basin structure	44.1
SK300080FK	Geothermal waters of the Žilinská kotlina Basin structure	406.0
SK300090FK	Geothermal waters of the Bánovská kotlina Basin structure	616.2
SK300100FK	Geothermal waters of the Hornonitrianska kotlina Basin structure	312.2
SK300110FK	Geothermal waters of the Turčianska kotlina Basin structure	411.8
SK300120FK	Geothermal waters of the Skorušinská panva Basin structure	433.9
SK300130FK	Geothermal waters of the Liptovská kotlina Basin structure	604.0
SK300140FK	Geothermal waters of the Levočská panva Basin structure - W and S part	1809.4
SK300150FK	Geothermal waters of the Levočská panva Basin structure - NE part	981.6
SK300160FK	Geothermal waters of the Humenné Ridge structure	988.6
SK300170FK	Geothermal waters of the Košická kotlina Basin structure	878.0
SK300180FK	Geothermal waters of the Komjatická depresia depression structure	323.5
SK300190FK	Geothermal waters of the Cental Slovakia neovolcanics structure - NW part	1507.4
SK300200FK	Geothermal waters of the Cental Slovakia neovolcanics structure - SE part	720.9
SK300210FK	Geothermal waters of the Levická kryha block structure	190.9
SK300220FK	Geothermal waters of the Rimavská kotlina Basin structure - N part	183.5
SK300220FK	Geothermal waters of the Rimavská kotlina Basin structure - S part	366.2
SK300230FP	Geothermal waters of the Beša-Čičarovce structure	142.2
SK300240PF	Geothermal waters of the Central depression of the Panonian Basin structure	3436.3

code	groundwater body name	area [km^2]
SK300250PF	Geothermal waters of the Dubník depression structure	857.1
SK300260FK	Geothermal waters of the Horné Strháre - Trenč graben structure	157.1

Annex C
Groundwater balancing in Slovakia

Brief history of groundwater balancing in Slovakia

After WW II, up to 1974, groundwater in Slovakia was classified and balanced within main watersheds. Although it was recognized also by authorities, that groundwatersheds are inconsistent with watershed in these times, only after completion of hydrogeological maps of 1 : 200 000 scale in mid seventies, 141 hydrogeological rayons (hydrogeological districts) were delineated for complex balancing. Those hydrogeological regions were selected according to the presence of main stratigraphical units (Crystalline – Mesozoic – Paleogene – Neogene – Quaternary), and possibility of closed groundwater circuit presence (infiltration – accumulation – output). The presence of main stratigraphical units is reflected in the abbreviation of the individual rayon's name. E.g. rayon code "P 119" is for "Paleogene of the Levočské vrchy Mts.", "Q 108" for "Quaternary of the Laborec river from Strážske to Stretava", "MG 077" for "Mesozoic and Paleozoic of the Starohorské vrchy Mts. and of the N part of the Zvolenská kotlina Basin".

Later, to keep the groundwater balance compatible with surface water balancing, individual hydrogeological rayons were sometimes cut by surface water divides, thus creating sub-units – hydrogeological sub-rayons. Also, different geological and hydrogeological settings lead sometimes into further divisions of hydrogeological rayons into another sub-unit type: partial hydrogeological rayons. Sub-rayons are marked by the main watershed abbreviation (e.g. NA for the Nitra river) + respective number code (the whole code "NA 10" for the sub-rayon No. 10 of the Nitra river watershed. Together 392 smaller sub-units were delineated within 141 major hydrogeological rayons. The list of 141 hydrogeological rayons (hydrogeological districts) is attached in annex ?? (Šuba et al. 1984).

Hydrogeological rayon is a basic unit for the groundwater balance. Unified territorial unit with equal hydrological settings delineated geologically, hydrogeologically and geomorphologically so that in this area it is possible to calculate the required elements of the groundwater water resource balance of natural groundwater resources, groundwater exploitable amounts and amount of groundwater intakes. Partial hydrogeological rayon structure in the framework of the hydrogeological region is based on the identical geological settings. Hydrogeological sub-rayon is a part of the hydrogeological rayon, dedicated to the one main watershed (Morava, Dunaj, Hron, Ipeľ, Slaná, Váh, Nitra, Bodva, Hornád, Bodrog & Poprad rivers).

Figure 1. Hydrogeological rayons in Slovakia (141 in total).

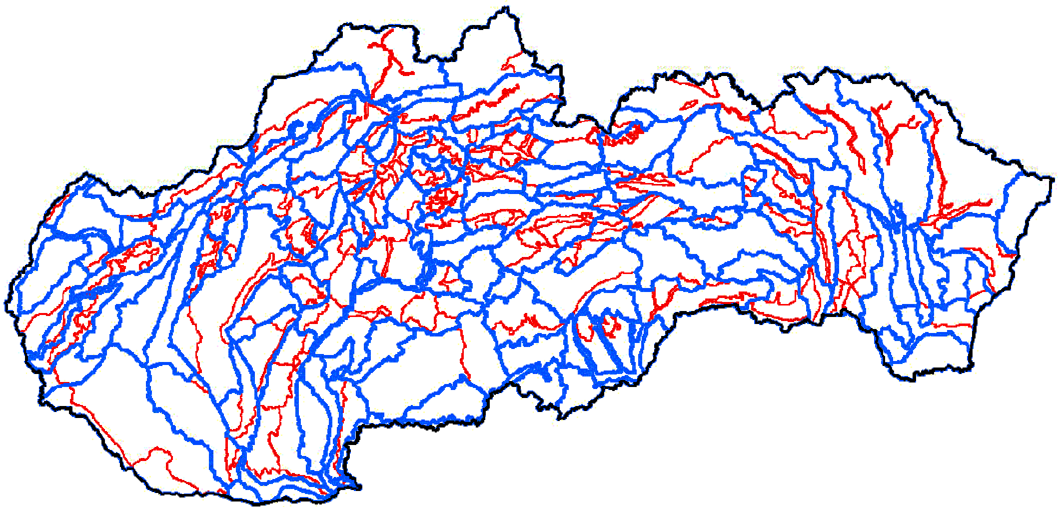


Figure 2. Hydrogeological sub-rayons in Slovakia (392 in total)

Principles of groundwater balancing in Slovakia

Annually, a report of each hydrogeological unit and sub-unit (rayon, sub-rayon, partial rayon) is completed within the framework of State Water Balance report, concerning quantitative evaluation of the abstraction and groundwater resources balance.
Since 1996, the structure of the State Water Balance report, Part Groundwater, is designed to contain informations on exploitable amounts and groundwater manipulation structured in respect to - hydrogeological regions and also balance profiles of the State Water Balance - Quantitative Water Management Balance, groundwater quality aspect based on data available (referred to drinking water standard STN 75 7111), division of exploitable groundwater amounts with links to the important localities from the water management point of view, where the exploitation ratio of groundwater is set and author's expertise estimation of the possibilities of exploitation increase / decrease where some evidence is present. An example of a typical table of a State Water Balance report, Part Groundwater is shown as Table 1.

The typical groundwater balancing table from the State Water Balance report for Slovak Republic, Part Groundwater starts with the whole hydrogeological region. It is then divided to the hydrogeological sub-regions or partial hydrogeological regions and also divided according to the balance profiles of the State Water Balance - Quantitative Water Management Balance.

Explanations to the groundwater balance table

- Investigation categories:

P1 - high state of hydrogeological investigations. Majority (>90 %) of the exploitable amounts approved by the KKZZ commission (groundwater resources and reserves commission).

P2 - good state of hydrogeological investigations. >50 % of the exploitable amounts approved by the KKZZ commission.

P3 - average state of hydrogeological investigations. Exploitable amounts partly approved by the KKZZ commission. High ratio of exploitable groundwater amounts in categories I., II., categories III. and "estimation" shown only marginally.

P4 - poor state of hydrogeological investigations. Exploitable amounts only in categories I., II., III., and "estimation". Areas without any hydrogeological investigations or research appear in the region. Poor state of the source data base.

P5 - insufficient state of hydrogeological investigations. Exploitable amounts only in categories I., II., III., and "estimation". High ratio of the exploitable amounts classified in categories III. and "estimation", categories I., II. shown only marginally, balance is based mainly on author's expertise.

Table 1: The typical groundwater balancing table from the State Water Balance report for Slovak Republic, Part Groundwater.

G-007 Prudká vrchovina hills Crystalline and Quaternary

Krepá watershed
area: 208,0 km^2
investigation cathegory: P3

Exploitable groundwater amounts: 274 $l.s^{-1}$ (4 - 0 - 12 - 18 / 50 - 60 - 0 - 110)

Intake (1999): 202,2 $l.s^{-1}$ purpose of exploitation (95,5 - 0,5 - 4,0 - 2,2 - 30,0 - 40,7 - 29,3)
Intake (1998): 178,1 $l.s^{-1}$
increase / decrease in comparison to the actual year: +24,1 $l.s^{-1}$

NOTE: prospective groundwater areas require additional hydrogeological investigations

KR 20 - Quaternary partial hydrogeological region
area: 42,0 km^2
to the total balance profile: 5050 (Huhlóc - Baretky above)
exploitable groundwater amounts: 54,0 $l.s^{-1}$ (0 - 0 - 0 - 46 / 0 - 8 - 0 - 0)
intake: 10,6 $l.s^{-1}$
balance status: good

balance profile: 6030 (Krepá - Hýril)
exploitable groundwater amounts: 22,0 l.s-1 (0 - 0 - 0 - 14 / 0 - 8 - 0 - 0)
intake: 5,6 $l.s^{-1}$
balance status: good

NAME OF THE LOCALITY	EXPLOITABLE AMOUNTS			ASSESMENT OF EXPLOITATION			
	cathegory	amount $l.s^{-1}$	quality	intake $l.s^{-1}$	exploitability	balance status Bs	note
Drobné Dvorčeky	C2	2,0	V	2,7	V4	havarijný	
Tupohryzy	C2 II.	4,0 6,0	V	1,2	V3	dobrý	+ 20,0 l.s-1 F
Vysoká Plávka	C2 C2	8,0 2,0	O	6,7	V3	kritický	+ 10,0 l.s-1 F

balance profile: 5050 (Huhlóc - Baretky above)
exploitable groundwater amounts: 32,0 $l.s^{-1}$ (0 - 0 - 0 - 32 / 0 - 0 - 0 - 0)
intake: 5,0 $l.s^{-1}$
balance status: good

NAME OF THE LOCALITY	EXPLOITABLE AMOUNTS			ASSESMENT OF EXPLOITATION			
	cathegory	amount $l.s^{-1}$	quality	intake $l.s^{-1}$	exploitability	balance status Bs	note
Kazihlavne	C2	12,0	V		V4	dobrý	+ P
Liliputánisko	C2	4,0	V		V4	dobrý	
Podlé Burácy	C2	7,0	V		V3	dobrý	+ 5,0 l.s-1 F
Mrákotné	C2	9,0	O		V3	dobrý	

- Exploitable groundwater amounts, e.g. 847 $l.s^{-1}$, is composed from several surveyed and estimated values of different categories.

874 $l.s^{-1}$ = (9 - 0 - 17 - 48 / 350 - 170 - 280 - 0)

A- category

B- category

C1 - category

C2 - category

I. - category

II. - category

III. - category

"estimation" category

- Intake (1999), e.g. 333,7 $l.s^{-1}$, is composed from several categories according to purpose of expoitation.

$$333{,}7\ l.s^{-1} = (114{,}6 - 0{,}2 - 0{,}0 - 206{,}6 - 0{,}0 - 7{,}7 - 4{,}6)$$

public waterworks

food industry

other industry

agriculture - animal farming

agriculture - plant farming + irrigations

social needs

other purposes

ANNEX D
Sub activity 1.6 Identification of groundwater bodies at risk

Sub-results 1a: Results of water quantity evaluation GWB at risk
The representative values for selecting groundwater bodies with “bad quantitative status” were abstracted from the **State Water Management Balance, part: Groundwater**, for the year of **2002**. In this annually published report, data on exploitable amounts of groundwater are pobilshed together with groundwater abstraction data. Groundwater abstraction data represent the results of data gathering by Slovak Hydrometeorological Institute (SHMI - SHMU) due to the obligatory declarations by organizations using groundwater according to the valid Regulation of Ministry of Environment No. 557/2002 dated on August 26, 2002 about the regulation practice of the Water Law. According to this Regulation send annually the average monthly records on abstraction, if these abstractions exceed 1250 m^3 per month, or 15000 m^3 per year, or if artesian groundwater is exploited. The basic unit for this groundwater balance is hydrogeological rayon. Hydrogeological rayon is unified territorial unit with equal hydrological settings delineated geologically, hydrogeologically and geomorphologically so that in this area it is possible to calculate the required elements of the groundwater water resource balance of natural groundwater resources, groundwater exploitable amounts and amount of groundwater intakes. As previously mentioned, hydrogeological rayon can be in some cases subsequently divided into hydrogeological sub-rayons and partial hydrogeological rayons.

In **2002**, total average groundwater abstraction in Slovakia reached **13.01317 $m^3.s^{-1}$**, as reported by groundwater users. The main part of this amount (**10.20177 $m^3.s^{-1}$**, e.i. 78.4 %) was used as a drinking water supply through pipeline systems. Thus, in 2002 the total abstraction of groundwater reached only **17.1 %** of total documented exploitable groundwater amounts. These figures document only an overall superficial glance at the whole reality, as such ration change from region to region. In some hydrogeological rayons, the ratio of abstraction and exploitable groundwater amounts reached 66 % (e.g. rayon PM 041), while in others it was only 1 % (e.g. rayon NG 113). The master criteria for selecting groundwater bodies with “bad quantitative status” was therefore proposed as aggregation of overall abstraction/exploitable groundwater amounts for the whole groundwater body and presence of overexploited sites. If the ratio of abstraction and exploitable groundwater amounts exceeds 50% or if at least 2 abstraction sites “emergency” or “critical” balance status (abstraction of more than 85% of exploitable groundwater amounts) occur on its territory, the “bad quantitative status” should be attributed to the whole groundwater body. For hydrogeological rayons with prevailing lower categories of exploitable amounts (categories “III.” and “estimate”), lower threshold for overall abstraction/exploitable groundwater amounts ratio was selected. If the sum of groundwater exploitable amounts in categories “III.” and “estimate” were higher than 25% of the total groundwater exploitable amounts for the whole hydrogeological rayon, e.i. the higher uncertainty degree of exploitable amounts knowledge was reached, the acceptable ratio of abstraction and exploitable groundwater amounts was decreased to 40%.

The results of such selection are listed in the **Table 1**. The reasons for which certain groundwater body was selected under quantitative risk are mentioned in the same table. Together, 10 groundwater bodies were selected to be under quantitative risk, 9 of them from the pre-Quaternary layer and one (SK1000100P) of the Quaternary layer. The ratio of abstraction and exploitable groundwater amounts > 50% as the only criteria was the reason for selection of one groundwater body (SK200080KF). The lower degree of certainty + higher degree of exploitation (> 40%) was the reason of selecting two groundwater bodies (SK2003800P & SK2004000P) – both dependent on the balance status of the NV 134 hydrogeological rayon. The presence of more than two abstraction sites in critical or emergency balance status of groundwater exploitation without other signs of overexploitation within the rayon (as ratio of abstraction and exploitable groundwater amounts) was the reason for selecting 4 groundwater bodies to be under quantitative risk (SK200270KF; SK200250KF; SK200410KF and SK1000100P). In the next three groundwater bodies (SK2001800F; SK200140KF; SK200460KF), both overall abstraction ratio and the presence of more than two abstraction sites in critical or emergency balance status of groundwater exploitation were detected.

Table 1 Quantitative status within groundwater body.

ID	Q / preQ	reason	name
SK2001800F	preQ	exploitation in PM 041 rayon = 66%; all 2 sites in QN 037 rayon are in critical or emergency status	Fissure groundwater body of the W part of flysch belt and podtatranská skupina group in the watershed area of Váh
SK200080KF	preQ	exploitation in M 045 rayon = 63%	Dominant karst-fissure groundwater body of Pezinské, Brezovské and Čachtické Karpaty Mts. in the watershed area of Váh
SK200140KF	preQ	exploitation in M 036 rayon = 53%; 3 sites in MP 066 rayon and 3 sites in M 032 rayon are in critical or emergency status	Dominant karst-fissure groundwater body of the Strážovské vrchy and Lúčanská Malá Fatra Mts. in the watershed area of Váh
SK200270KF	preQ	2 sites in M 020 rayon, 2 sites in M 023 rayon and 2 in M 024 rayon are in critical or emergency status	Dominant karst-fissure groundwater body of the Veľká Fatra, Chočské vrchy and Západné Tatry Mts. in the watershed area of Váh
SK200250KF	preQ	2 sites in M 023 rayon and 2 in M 024 rayon are in critical or emergency status	Dominant karst-fissure groundwater body of the Veľká Fatra Mts. in the watershed area of Hron
SK200460KF	preQ	exploitation in MG 013 rayon = 52%; 2 sites in MG 117 rayon are in critical or emergency status	Dominant karst-fissure groundwater body of the Slovenský Raj and Galmus Mts. in the watershed area of Hornád
SK200410KF	preQ	3 sites in MG 013 rayon are in critical or emergency status	Fissure and karst-fissure groundwater body of the E of Nízke Tatry Mts. in the watershed area of Váh
SK1000100P	Q	3 sites in Q 001 rayon are in critical or emergency status	Intergranular groundwater body of the Vienna Basin Quaternary sediments in the Danube watershed area

ID	Q / preQ	reason	name
SK2004000P	preQ	high relative portion (> 25%) of the "III." and "estimate" categories + exploitation > 40 %; exploitation in NV 134 rayon = 41%	Intergranular groundwater body of the Valická pahorkatina hills in the watershed area of Hron
SK200380FP	preQ	high relative portion (> 25%) of the "III." and "estimate" categories + exploitation > 40 %; exploitation in NV 134 rayon = 41%	Fissure and intergranular groundwater body of the neovolcanoes of Pokoradzská tabuľa Plateau

Figure 1: Quantative risk: Quaternary groundwater bodies

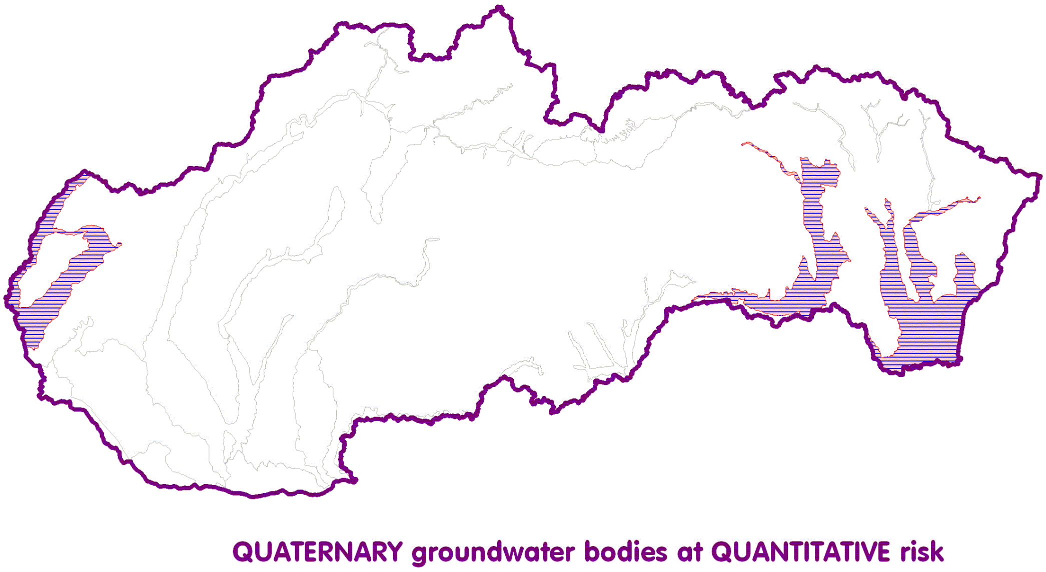
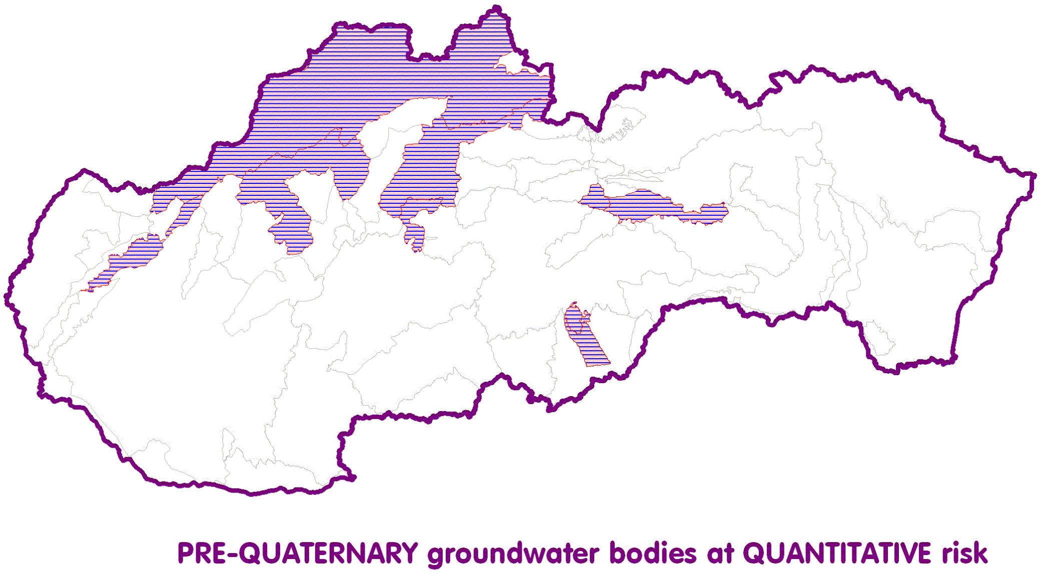


Figure 2: Quantative risk: Pre-Quaternary groundwater bodies



Sub-results 1b: Results of water quality evaluation GWB at risk

Figure 3: Present groundwater quality: Pre-Quaternary groundwater bodies (red=bad quality status)

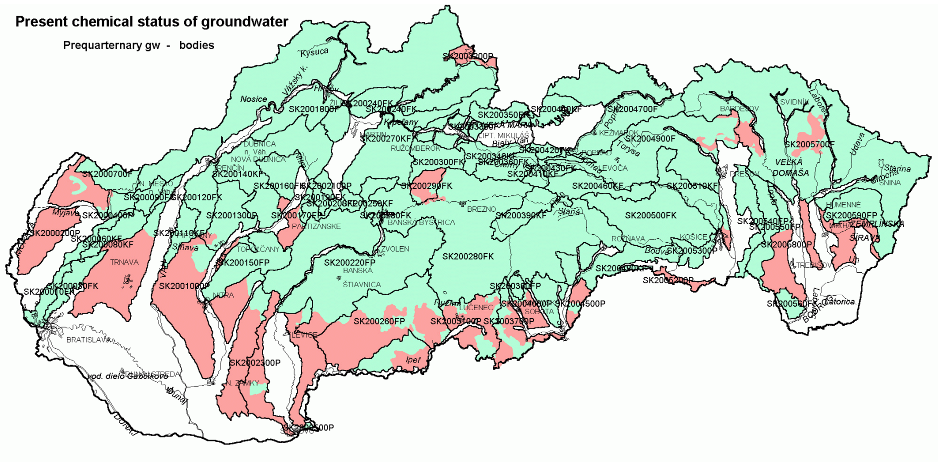


Figure 4: Present groundwater quality: Quaternary groundwater bodies

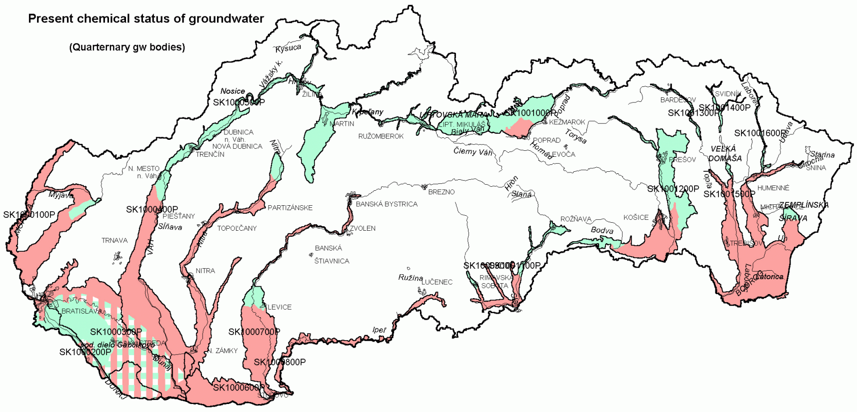


Figure 5: Diffuse and point sources: pollution risk (red=high, orange=intermediate and green = low pollution risk)

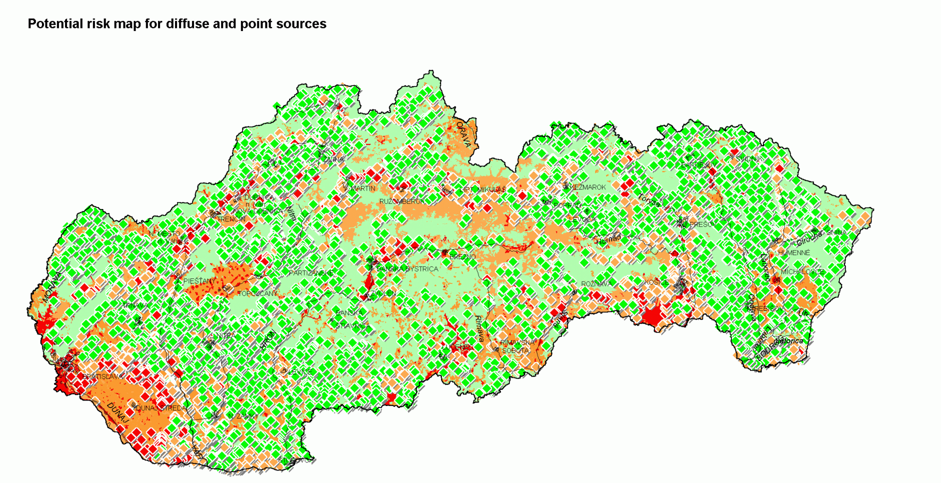


Figure 6: Vulnerability map

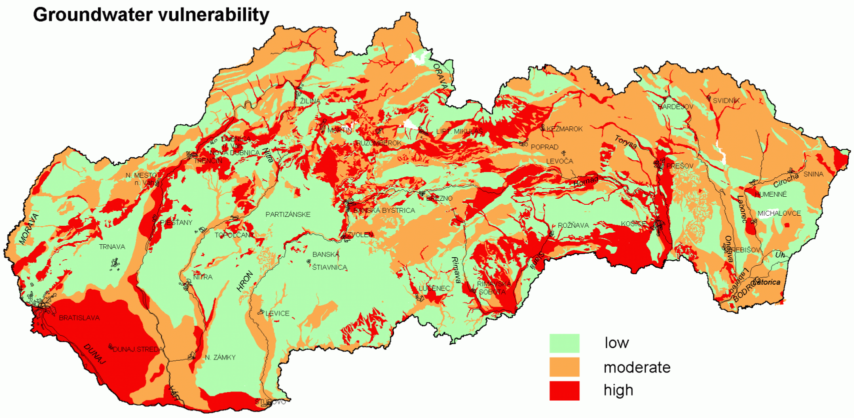


Figure 7: Qualitative risk: Quaternary groundwater bodies

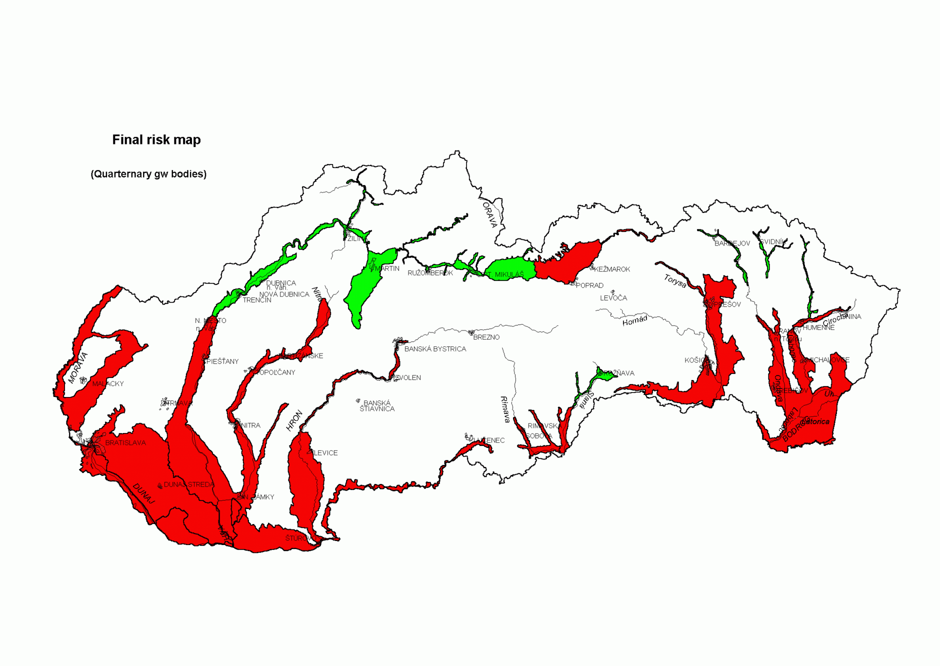
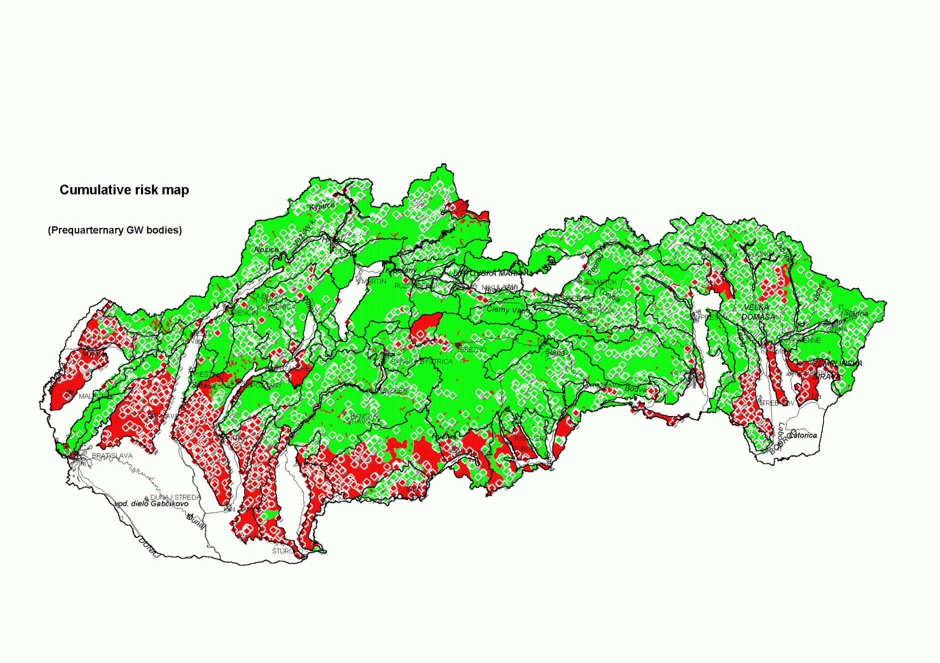


Figure 8: Qualitative risk: Pre-Quaternary groundwater bodies



Result 1: Combined maps of GWB at risk

Figure 9: Combines risk: Quaternary groundwater bodies

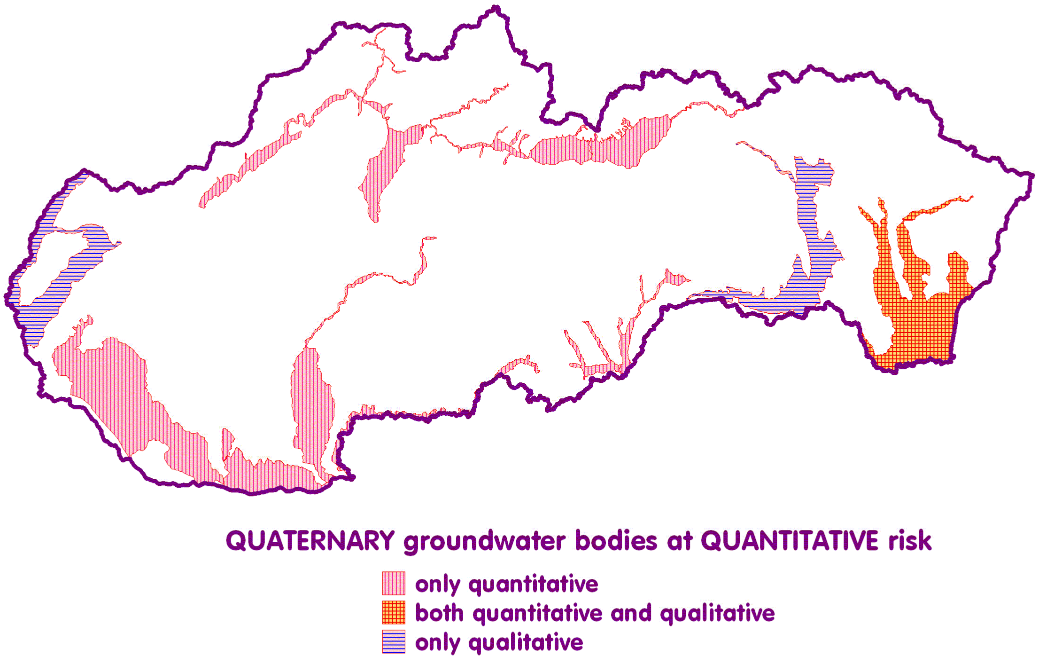
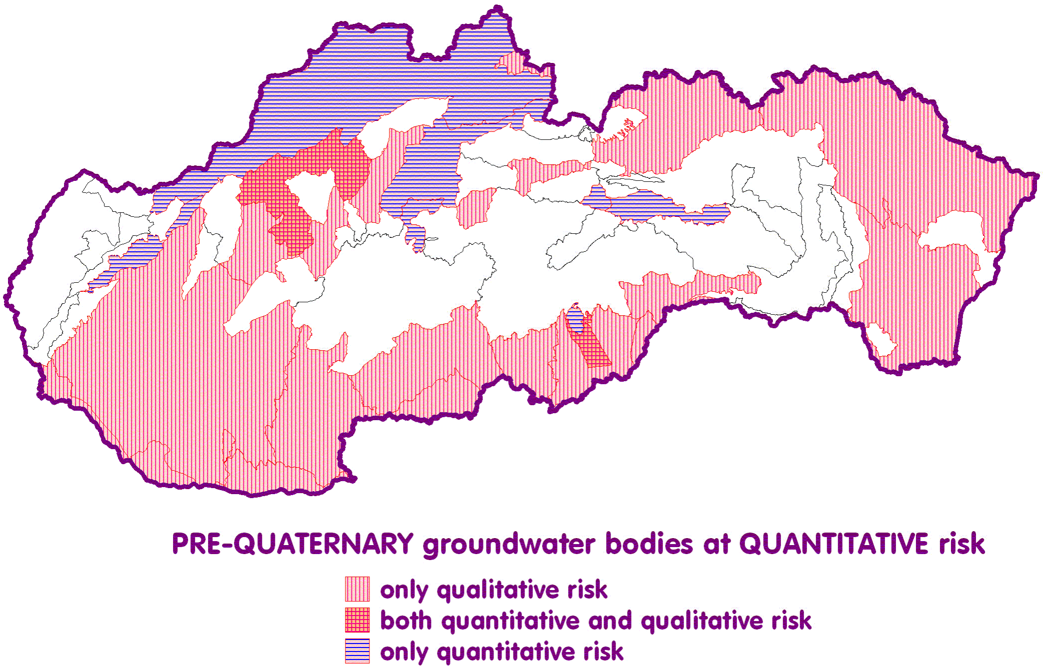


Figure 9: Combines risk: Pre-Quaternary groundwater bodies



Annex E
Geoenviron method for evaluation of points sources risk

Sum of groundwater risk was used from the final risk score. Calculated risk represents only potential risk because required input data are not available in the vicinity of each source of contamination (such as detailed characterization of abiotic content, monitoring objects etc.)

Calculation of groundwater risk related to the specific locality is based on the partial scores for:
(A) groundwater classes

(B) groundwater vulnerability

(C, D, E, F) characteristic of contaminant (mobility, toxicity, degradation, amount)

Total score of groundwater risk (G) is computed as a sum of partial scores of groundwater classes (A), vulnerability classes (B), mobility classes (C), toxicity (D), degradation (E) and contaminant amount (F):
G = A + B + Max. (C + D + E + F)

Low: G=<20, Moderate: G=20-30, High: G=>

Groundwater classes characterize the water management significance of area on which the industrial site is located. Based on the groundwater classes presented in the map a following score is assigned to the industrial sites:

Class	Title	Score
3.	Water management area with high priorities	12
2.	Water management area with priorities	6
1.	Water management area with no or low interests	0

Based on the groundwater vulnerability presented in the map a following score is assigned to the industrial sites:

Class	Title	Score
3.	No or very low natural protection	6
2.	Moderate natural protection	3
1.	Good natural protection	0

The following parameters evaluate contaminant properties:
- mobility;
- toxicity;
- degradation;
- amount.

Partial score assigned to the each mentioned parameter follows both the information given in the GeoEnviron information system and criteria discussed in the next text. If more than one contaminant occurs in the specific locality only that with the highest total score is considered in the final calculation.

Mobility classes
The octanol/water partition coefficient (K_{ow}) determines a mobility of organic compounds. The mobility of inorganic compounds is given by the water/solid-phase (rocks, soil fragments etc.) partition coefficient (K_d). Low values of K_{ow} and K_d represent a good mobility and vice versa. Subsequently, a following score is assigned to the industrial sites:

Class	Title	Log K_{ow} or K_d	Score
3.	High mobility	> 3	6
2.	Moderate mobility	3 – 4	3
1.	Low mobility	> 4	0

Toxicity classes
Basically, the toxicity classes are defined as a target concentration of contaminant in groundwater based on the lethal dose. Then, a following score is assigned to the industrial sites:

Class	Title	Log K_{ow} or K_d	Score
3.	High mobility	< 1 $\mu g.l^{-1}$	4
2.	Moderate mobility	1 – 10 $\mu g.l^{-1}$	2
1.	Low mobility	> 10 $\mu g.l^{-1}$	0

Degradation classes
The time needed for the decomposition of compound to the intoxic substance in anaerobic conditions is base for the classification of degradation processes. Based on the decomposition rate a following score is assigned to the industrial sites:

Class	Title	Score
3.	High decomposition rate	1
2.	Moderate decomposition rate	2
1.	Low decomposition rate	4

Ranking of amount of chemical constituent
Amount of compound characterizes the amount of chemical substance in the specific locality. The score given to the individual classes increase exponentially due to the seriousness of this category in the conditions of Slovakia.

Class	Amount	Score
1.	<1t	0
2.	1 – 10 t	2
3.	10 – 100 t	4
4.	100 – 1000 t	8
5.	> 1000 t	16

Annex F
Overview of the 141 hydrogeological rayons (hydrogeological districts) with code and name.

Code	Name of the hydrogeological rayon
Q 001	Quaternary of the Morava river and Brodské
N 002	Neogene of the Chvojnica Hills
Q 003	Quaternary of the Myjava river
Q 004	Quaternary of the Morava river from Brodské to Vysoká pri Morave
NQ 005	Neogene of the central part of the Borská nížina Lowland
QN 006	Quaternary and Neogene of the NE part of the Malé Karpaty Mts.
Q 007	Quaternary and Neogene of the S and SE part of the Borská nížina Lowland
MG 008	Crystalline and Mesozoic of SW part of the Malé Karpaty Mts.
Q-G 009	Crystalline of the Západné Tatry Mts. and Quaternary of the E part of the Liptovská kotlina Basin
M 010	Mesozoic of the chočský príkrov nappe of the NE slopes of Nízke Tatry and Kozie chrbty Mts.
MG 011	Paleozoic and Mesozoic of the Ipoltica unit of the NE slopes of Nízke Tatry and Kozie chrbty Mts.
MG 012	Mesozoic of Veľký Bok series - western and central part and adjacent crystallin of the NE slopes of Nízke Tatry Mts.
MG 013	Mesozoic of Veľký Bok - E part and adjacent crystallin of the NE slopes of Nízke Tatry
MG 014	Mesozoic and adjacent crystallin of Západné Tatry Mts. in Orava river watershed
M 015	Mesozoic of the E part of Chočské vrchy Mts.
QP 016	Paleogene and Quaternary of the W and central part of the Liptovská kotlina Lowland
MG 017	Mesozoic and crystallin of the NW slopes of Nízke Tatry Mts.
PQ 018	Paleogene of the Oravská vrchovina Hills
M 019	Mesozoic of W part of the Chočské vrchy Mts.
M 020	Mesozoic of N part of the Veľká Fatra Mts.
G 021	Crystalline of the Veľka Fatra Mts.
M 022	Mesozoic of Veľká Fatra Mts. (area between Smrekovica and Ploská)
M 023	Mesozoic of the chočský príkrov nappe of W part of the Veľká Fatra Mts.
M 024	Mesozoic of Veľká Fatra Mts. and Nízke Tatry Mts. (area between Ploská and Donovaly)
PN 025	Paleogene of the Biela Orava watershed and Neogene of the Oravská kotlina Basin
MP 026	Mesozoic of the Clippen belt and Paleogen in Varínka river watershed
MG 027	Mesozoic and crystallin of the Krivánska Fatra Mts.
PQ 028	Paleogene of the Kysuca catchment
QP 029	Paleogene and Quaternary of the part of the Žilinská kotlina Basin and E margin of the Súľovské vrchy Mts.
MG 030	Crystalline and Mesozoic of the NW slopes of the Lúčanská Fatra Mts.
MG 031	Crystalline and Mesozoic of the NE part of the Lúčanská Fatra Mts.
M 032	Mesozoic of the S part of the Lúčanská Fatra Mts.
QP 033	Paleogene, Neogene and Quaternary of the Turčianska kotlina Basin
MP 034	Paleogene and Mesozoic of the Clippen belt of the Súľovské vrchy Mts. and Podmanínska pahorkatina Hills
M 035	Mesozoic of the N part of the Strážovské vrchy Mts.
M 036	Mesozoic of the NW part of the Strážovské vrchy Mts.
QN 037	Quaternary and Neogene of the Ilavská kotlina Basin
QM 038	Quaternary of the Trenčianska kotlina Basin and adjacent Mesozoic of the Trenčianska vrchovina Hills
Q 039	Quaternary of the Bytčianska kotlina Basin

Code	Name of the hydrogeological rayon
PM 040	Paleogene and Mesozoic of the Clippen belt of Javorníky Mts. and of NE part of Biele Karpaty Mts.
PM 041	Paleogene and Mesozoic of the Clippen belt of Vlára river
MG 42	Paleogene and Mesozoic of the Clippen belt of E part of the Biele Karpaty Mts. and N part of Paleogene and Mesozoic of the Clippen belt of the E part of the Biele Karpaty Mts. and N part of the Myjavská pahorkatina Hills
PM 043	Paleogene and Mesozoic of the Clippen belt of the W part of the Biele Karpaty Mts.
NM 044	Neogene to Cretaceous of the Myjavská pahorkatina Hills SW from the Clippen belt
M 045	Mesozoic of the Čachcické Karpaty Mts. and of the part of the Bielokarpatské podhorie
MG 046	Mesozoic and Paleozoic of the NW part of Považský Inovec Mts.
MG 047	Mesozoic of the central and S part of the Považský Inovec Mts.
Q 048	Quaternary of the Váh river in the Podunajská nížina Lowland, N-ward from the Šaľa - Galanta axis
N 049	Neogene of the Trnavská pahorkatina Hills
Q 050	Quaternary of the Trnavská pahorkatina Hills
Q 051	Quaternary of the W margin of the Podunajská nížina Lowland
Q 052	Quaternary of the SW part of the Podunajská nížina Lowland
MN 053	Mesozoic of the N part of the Pezinské and Brezovské Karpaty Mts.
M 054	Mesozoic of the Krížna nappe of the the Malé Karpaty Mts.
MG 055	Crystalline and Mesozoic of the SE part of the Pezinské Karpaty Mts.
Q 056	Quaternary of the Dunaj river between Komárno and Chľaba
Q 057	Quaternary of Dunaj river terraces at the base of the Hronská pahorkatina Hills
N 058	Neogene of the Hronská pahorkatina Hills
QN 059	Quaternary of Hron terraces in the Podunajská nížina Lowland
Q 060	Quaternary of the Hron flood plain in the Podunajská nížina Lowland
N 061	Neogene of the central and S part of the Ipeľská pahorkatina Hills
N 062	Neogene of the Bátovská pahorkatina Hills and Čajkovská zníženina Depression
P-Q 063	Crystalline, Mesozoic and Paleogene of the SW part of the Žiar Mts. and Handlovská kotlina Basin
M 064	Mesozoic of the N part of Žiar Mts.
P-G 065	Mesozoic and Paleogene of the E part of the Strážovské vrchy Hills
MP 066	Mesozoic and Paleogen of the S part of Strážovské vrchy Mts.
QN 067	Neogene and Quaternary of the Hornonitrianska kotlina Basin
GM 068	Crystalline and Mesozoic of the E part of the Považský Inovec Mts.
MG 069	Mesozoic and Paleozoic of the NE part of the Tríbeč Mts.
MG 070	Crystalline and Mesozoic of the S and central part of the Tríbeč Mts.
NQ 071	Neogene of the Nitrianska pahorkatina Hills
Q 072	Quaternary of the Žitavská pahorkatina Hills
NQ 073	Neogene of the Žitavská pahorkatina Hills
Q 074	Quaternary of the Podunajská rovina lowland intra-watershed
QG 075	Crystalline and Mesozoic of the SW slopes of the Nízke Tatry Mts.
MG 076	Crystalline and Mesozoic of the SW slopes of Nízke Tatry Mts.
MG 077	Mesozoic and Paleozoic of the Starohorské vrchy Mts. and of the N part of the Zvolenská kotlina Basin
MG 078	Mesozoic and pre-Mesozoic rocks of the E part of the Zvolenská kotlina Basin and of the NW part of the Veporské vrchy Mts.
MP 079	Mesozoic of the Kremnické vrchy Mts. and of the W part of the Zvolenská kotlina Basin
Q 080	Quaternary of the Hron and Slatina rivers from Slovenská Ľupča to Tlmače
NQ 081	Neogene of the Zvolenská kotlina Basin - W part

Code	Name of the hydrogeological rayon
V 082	Neovolcanoes of the Kremnické vrchy Mts.
V 083	Neovolcanoes of the Poľana Mts. And part of the Zvolenská kotlina Basin
NV 084	Neogene of the Zvolenská kotlina Basin - E part
G 085	Crystalline of the Detvianska kotlina Basin and Sihlianska planina Plateau in the Slatina watershed
V 086	Neovolcanoes of the Vtáčnik and Pohronský Inovec Mts.
N 087	Neogene of the Žiarska kotlina Basin
V 088	Neovolcanoes of the N slopes of Štiavnické vrchy and Javorie Mts.
GN 089	Crystalline of the Revúcka vrchovina and Stolické vrchy Mts. in the Ipeľ watershed
NQ 090	Neogene of the Lučenská kotlina Basin
Q 091	Quaternary of Ipeľ river
NV 092	Neogene of the W part of Cerovská vrchovina Mts.
V 093	Neovolcanoes of the S slopes of Štiavnické vrchy and Javorie Mts.
V 094	Neovolcanoes of the Krupinská planina Plateau, Ostrôžky and Pôtorská pahorkatina Hills
NQ 095	Neogene of the Ipeľská kotlina Basin
V 096	Neovolcanoes of the Burda Mts.
QPM 097	Paleogene and Quaternary of the Laborec river up to Brekov and Mesozoic of the Humenské vrchy Mts.
P 098	Paleogene of the Uh watershed
VNP 100	Neovolcanoes of the Vihorlatské vrchy Mts.
NQ 101	Neogene of the Východoslovenská nížina lowland between Laborec and Čierna voda rivers
QN 102	Quaternary of the NE part of the Východoslovenská nížina lowland under the Vihorlat and Popričný Mts.
QN 103	Quaternary of the lower parts of rivers Uh, Laborec, Ondava and right side of the Latorica river
QN 104	Quaternary of the SE part of the Východoslovenská nížina lowland
PQ 105	Paleogene of the Ondava river up to Kučín
QN 106	Quaternary of the Ondava and Topľa rivers from Slovenská Kajňa to Trebišov
N 107	Neogene of the Pozdišovský chrbát Mts. and Malčická tabuľa Plateau
Q 108	Quaternary of the Laborec river from Strážske to Stretava
PQ 109	Paleogene of the Čergov Mts.
PQ 110	Paleogene of the Nízke Beskydy Mts. In the Topľa watershed
VN 111	Neovolcanoes of the Slanské vrchy Mts.
N 112	Neogene of the W part of the Východoslovenská nížina lowland
NG 113	Paleozoic nad upper members of the Zemplínske vrchy Mts.
Q 114	Quaternary of the lower part of the Roňva river
PQ 115	Paleogene of the Hornádska kotlina Basin and part of the Popradská kotlina Basin
MG 116	Mesozoic of the Slovenský raj and Havranie vrchy Mts. with adjacent Paleozoic
MG 117	Mesozoic of the Galmus Mts. and adjacent Paleozoic
G 118	Paleozoic of the Slovenské Rudohorie Mts. in the Hornád watershed
P 119	Paleogene of the Levočské vrchy Mts.
QP 120	Paleogene of the Spišsko-šarišské medzihorie Mts., Bachureň and Šarišská vrchovina Mts. in the Torysa watershed
MG 121	Mesozoic and Paleozoic of the Branisko Mts.
P 122	Paleogene of the Svinka watershed
NQ 123	Neogene of the E part of the Košická kotlina Basin
MG 124	Mesozoic and Crystalline of the Čierna hora Mts.

Code	Name of the hydrogeological rayon
Q 125	Quaternary of the Hornád river in the Košická kotlina Basin
M 126	Mesozoic of the Muránska Planina Plateau and the E part of the Heľpianske podolie Valley and adjacent Crystallin
G 127	Crystalline of the Stolické vrchy Mts. and Revúcka vrchovina Mts. in the Slaná watershed
G 128	Paleozoic of the Revúcka vrchovina and Volovské vrchy Mts. in the Slaná watershed
MQ 129	Mesozoic of the central and E part of the Slovenský kras Mts.
M 130	Mesozoic of W part of the Slovenský kras Mts., Železnícke podhorie and part of the Licinská pahorkatina Hills
NM 131	Neogene of the Gemerská pahorkatina Hills
Q 132	Quaternary of the Rimavská kotlina Basin
NV 133	Neogene of the central part of the Rimavská kotlina Basin
NV 134	Neogene of the W part of the Rimavská kotlina Basin
NV 135	Neogene of the E part of the Cerová vrchovina Mts.
N 136	Neogene of the W part of the Oždianska pahorkatina Hills
G 137	Paleozoic of the Volovské vrchy Mts. in the Bodva watershed
NQ 138	Neogene and Quaternary of the Košická kotlina Basin and Abovská pahorkatina Hills in the Bodva watershed
QG 139	Crystalline of tha part of the Vysoké Tatry Mts. And Quaternary of its foreland
M 140	Mesozoic of the part of the Kozie chrbty Mts.
PQ 141	Paleogene of the Spišská Magura Mts., Ľubovnianska vrchovina Mts. and NW part of the Spišsko-šarišské medzihorie and Pieniny Mts.
MG 142	Mesozoic and adjacent crystallin of the Vysoké and Belianske Tatry Mts.

ANNEX G
FURTHER CHARACTERIZATION

Further characterization of flow characteristics

Table 1: Groundwater bodies at risk with characteristics of hydraulic conductivity (range, average), anisotropy, porosity (primary / secondary) & confinement.

ID (code)	type of risk	hydraulic conductivity range	anisotropy	porosity	confinement
SK2000500P	qualitative risk	1E-6 to 5E-3 m/s	high vertical heterogeneity	primary	confined
SK200080KF	quantitative risk	> 1E-3 m/s	high vertical and horizontal heterogeneity	secondary	phreatic
SK2001000P	qualitative risk	1E-6 to 5E-3 m/s	high vertical heterogeneity	primary	confined
SK2001300P	qualitative risk	1E-6 to 5E-3 m/s	high vertical heterogeneity	primary	confined
SK200140KF	quantitative and qualitative risk	1E-5 to 1E-2 m/s	high vertical and horizontal heterogeneity	secondary	phreatic
SK200170FP	qualitative risk	1E-5 to 1E-4 m/s	vertical and horizontal heterogeneity	both primary and secondary	both phreatic and confined
SK2001800F	quantitative risk	1E-5 to 1E-4 m/s	exponential decrease of permeability downwards	secondary	phreatic
SK2002100P	qualitative risk	1E-5 to 1E-4 m/s	relatively homogenous	primary	phreatic
SK2002300P	qualitative risk	1E-6 to 5E-3 m/s	high vertical heterogeneity	primary	confined
SK200250KF	quantitative risk	1E-5 to 1E-2 m/s	high vertical and horizontal heterogeneity	secondary	phreatic
SK200260FP	qualitative risk	1E-5 to 1E-4 m/s	vertical and horizontal heterogeneity	both primary and secondary	both phreatic and confined
SK200270KF	quantitative risk	1E-5 to 1E-2 m/s	high vertical and horizontal heterogeneity	secondary	phreatic
SK200290FK	qualitative risk	1E-5 to 1E-2 m/s	high vertical and horizontal heterogeneity	secondary	phreatic
SK2003100P	qualitative risk	1E-6 to 1E-4 m/s	high vertical heterogeneity	primary	confined
SK2003200P	qualitative risk	1E-6 to 1E-4 m/s	high vertical heterogeneity	primary	confined
SK200340KF	qualitative risk	1E-5 to 1E-2 m/s	high vertical and horizontal	secondary	phreatic

ID (code)	type of risk	hydraulic conductivity range	anisotropy	porosity	confinement
			heterogeneity		
SK2003700P	qualitative risk	1E-6 to 1E-4 m/s	high vertical heterogeneity	primary	confined
SK200380FP	quantitative risk	1E-5 to 1E-4 m/s	vertical and horizontal heterogeneity	both primary and secondary	both phreatic and confined
SK2004000P	quantitative and qualitative risk	1E-6 to 1E-4 m/s	high vertical heterogeneity	primary	confined
SK200410KF	quantitative risk	1E-5 to 1E-2 m/s	high vertical and horizontal heterogeneity	secondary	phreatic
SK2004500P	qualitative risk	1E-6 to 1E-4 m/s	high vertical heterogeneity	primary	confined
SK200460KF	quantitative risk	1E-5 to 1E-2 m/s	high vertical and horizontal heterogeneity	secondary	phreatic
SK2004700F	qualitative risk	1E-5 to 1E-4 m/s	exponential decrease of permeability downwards	secondary	phreatic
SK200480KF	qualitative risk	> 1E-3 m/s	high vertical and horizontal heterogeneity	secondary	phreatic
SK2005700F	qualitative risk	1E-5 to 1E-4 m/s	exponential decrease of permeability downwards	secondary	phreatic
SK2005800P	qualitative risk	1E-6 to 5E-3 m/s	high vertical heterogeneity	primary	confined
SK1000300P	qualitative risk	1E-4 to 1E-2 m/s	vertical anisotropy > horizontal	primary	phreatic
SK1000500P	qualitative risk	1E-4 to 1E-2 m/s	vertical anisotropy > horizontal	primary	phreatic
SK1000600P	qualitative risk	1E-5 to 1E-3 m/s	vertical anisotropy > horizontal	primary	phreatic
SK1000700P	qualitative risk	1E-5 to 1E-3 m/s	vertical anisotropy > horizontal	primary	phreatic
SK1000800P	qualitative risk	1E-4 to 1E-3 m/s	vertical anisotropy > horizontal	primary	phreatic
SK1000900P	qualitative risk	1E-5 to 1E-3 m/s	vertical anisotropy > horizontal	primary	phreatic

ID (code)	type of risk	hydraulic conductivity range	anisotropy	porosity	confinement
SK1001000P	qualitative risk	1E-5 to 1E-4 m/s	vertical anisotropy > horizontal	primary	phreatic
SK1001100P	qualitative risk	1E-5 to 1E-3 m/s	vertical anisotropy > horizontal	primary	phreatic
SK1001500P	quantitative and qualitative risk	1E-5 to 1E-3 m/s	vertical anisotropy > horizontal	primary	phreatic
SK1000100P	quantitative risk	1E-4 to 1E-2 m/s	vertical anisotropy > horizontal	primary	phreatic
SK1001200P	quantitative risk	1E-5 to 1E-3 m/s	vertical anisotropy > horizontal	primary	phreatic

Further characterization of quantative pressures

Final results of groundwater level / groundwater discharge trends in time (1980-2003) for both Quaternary and pre-Quaternary groundwater bodies are listed in Tables 2 and 3. The situation is also presented on Figs 1, 2 and 3.

Table 2 Final results of groundwater level / groundwater discharge trends in time (1980-2003) for Quaternary groundwater bodies.

GW body ID	total sum of weights	number of values within GW body	CAT. 5: values less than -2*σ	CAT. 4: values between -2*σ and -1*σ	CAT. 3: values between -1*σ and +1*σ	CAT. 2: values between +1 and +2*σ	CAT. 1: values more than +2*σ
SK1000100P	1	23	1	2	14	6	0
SK1000200P	37	64	10	6	13	16	19
SK1000300P	26	132	10	11	70	28	13
SK1000400P	19	128	5	20	67	27	9
SK1000500P	-10	61	9	12	27	5	8
SK1000600P	3	34	0	4	25	4	1
SK1000700P	-7	63	6	10	36	6	5
SK1000800P	0	17	2	1	9	4	1
SK1000900P	-3	10	0	3	7	0	0
SK1001000P	0	11	0	5	3	2	1
SK1001100P	-7	13	1	4	8	0	0
SK1001200P	-29	44	7	13	19	5	0
SK1001300P	-7	4	2	1	1	0	0

GW body ID	total sum of weights	number of values within GW body	CAT. 5: values less than -2*σ	CAT. 4: values between -2*σ and -1*σ	CAT. 3: values between -1*σ and +1*σ	CAT. 2: values between +1 and +2*σ	CAT. 1: values more than +2*σ
SK1001400P	-1	1	0	1	0	0	0
SK1001500P	-43	76	6	28	39	3	0
SK1001600P	-12	6	3	3	0	0	0
SUM:	-33	687	62	124	338	106	57

Table 3 Final results of groundwater level / groundwater discharge trends in time (1980-2003) for pre-Quaternary groundwater bodies.

GW body ID	**total sum of weights**	**number of values within GW body**	**CAT. 5: values less than -2*σ**	**CAT. 4: values between -2*σ and -1*σ**	**CAT. 3: values between -1*σ and +1*σ**	**CAT. 2: values between +1 and +2*σ**	**CAT. 1: values more than +2*σ**
SK200010FK	**-1**	1	0	1	0	0	0
SK2000200P	**-1**	2	0	1	1	0	0
SK200060KF	**0**	1	0	0	1	0	0
SK2000700F	**0**	1	0	0	1	0	0
SK200080KF	**0**	2	0	0	2	0	0
SK200110KF	**-3**	2	1	0	1	0	0
SK200140KF	**9**	11	1	0	4	3	3
SK200150FP	**0**	3	0	1	1	1	0
SK2001800F	**-3**	4	1	0	3	0	0
SK200220FP	**2**	8	0	1	6	0	1
SK2002300P	**-6**	4	2	1	0	1	0
SK200240FK	**4**	2	0	0	0	1	1
SK200250KF	**0**	2	0	0	2	0	0
SK200270KF	**0**	13	1	3	5	3	1
SK200280FK	**4**	12	0	0	10	1	1
SK200290FK	**-1**	3	0	2	0	1	0
SK2003300F	**1**	3	0	0	2	1	0
SK200340KF	**-2**	4	0	2	2	0	0
SK200360FK	**1**	3	0	0	2	1	0
SK200390KF	**0**	2	0	0	2	0	0
SK2004000P	**-1**	1	0	1	0	0	0
SK200460KF	**-7**	11	1	5	4	1	0
SK2004700F	**-3**	2	1	0	1	0	0
SK200480KF	**-2**	9	0	2	7	0	0
SK2004900F	**0**	1	0	0	1	0	0

GW body ID	total sum of weights	number of values within GW body	CAT. 5: values less than -2*σ	CAT. 4: values between -2*σ and -1*σ	CAT. 3: values between -1*σ and +1*σ	CAT. 2: values between +1 and +2*σ	CAT. 1: values more than +2*σ
SK200500FK	**-1**	4	0	1	3	0	0
SK200510KF	**1**	3	0	0	2	1	0
SK2005300P	**3**	1	0	0	0	0	1
SK200540FP	**3**	1	0	0	0	0	1
SK200550FP	**0**	1	0	0	1	0	0
SK2005700F	**-3**	3	0	3	0	0	0
SUM:	**-6**	**120**	**8**	**24**	**64**	**15**	**9**

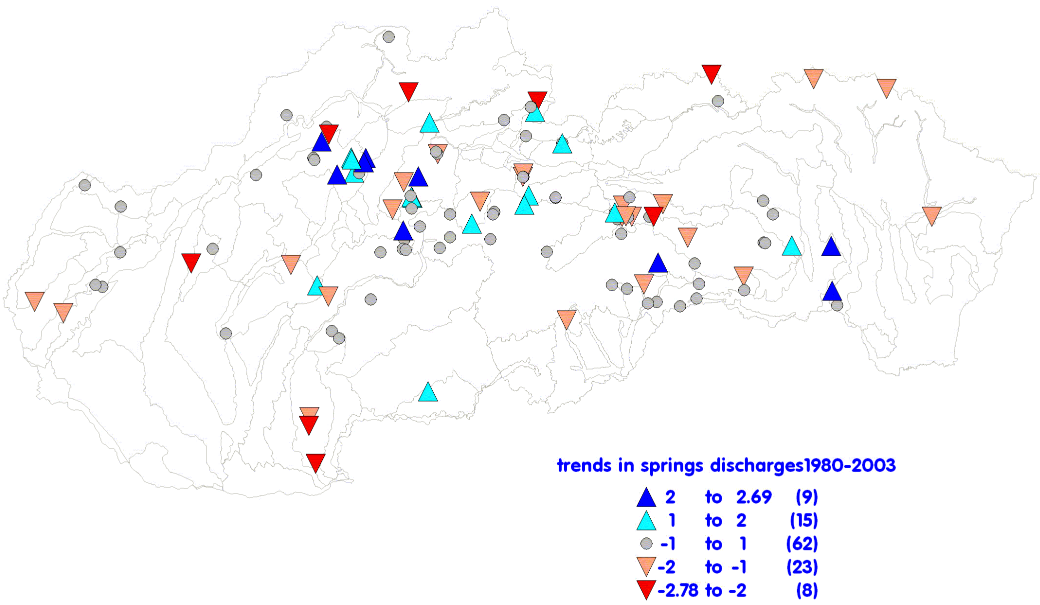


Figure 1: Long-term trends in springs' discharges in the period of 1980-2003.

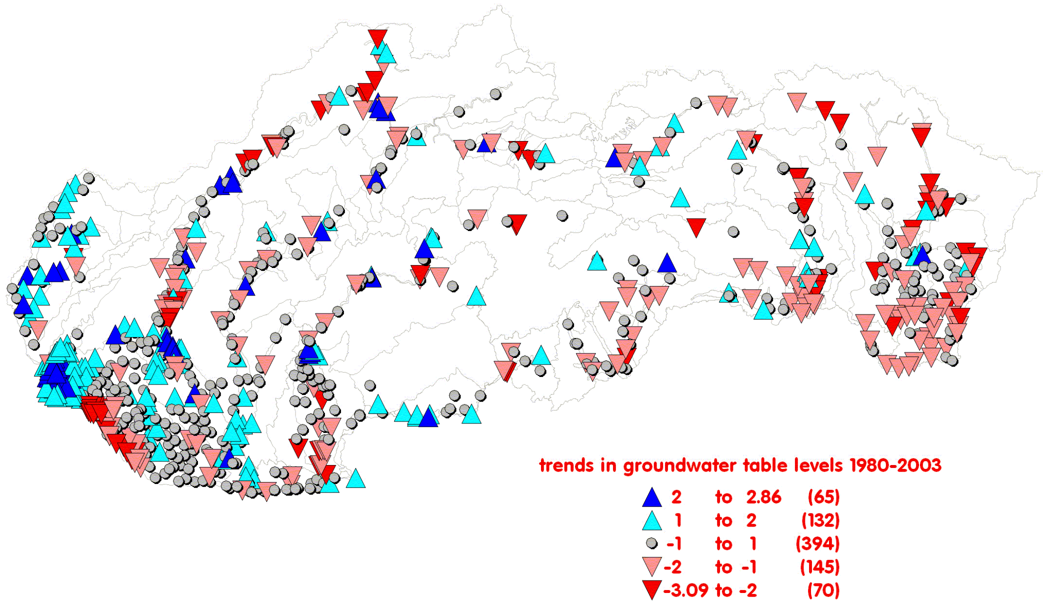


Figure 2 Long-term trends in groundwater levels in the period of 1980-2003.

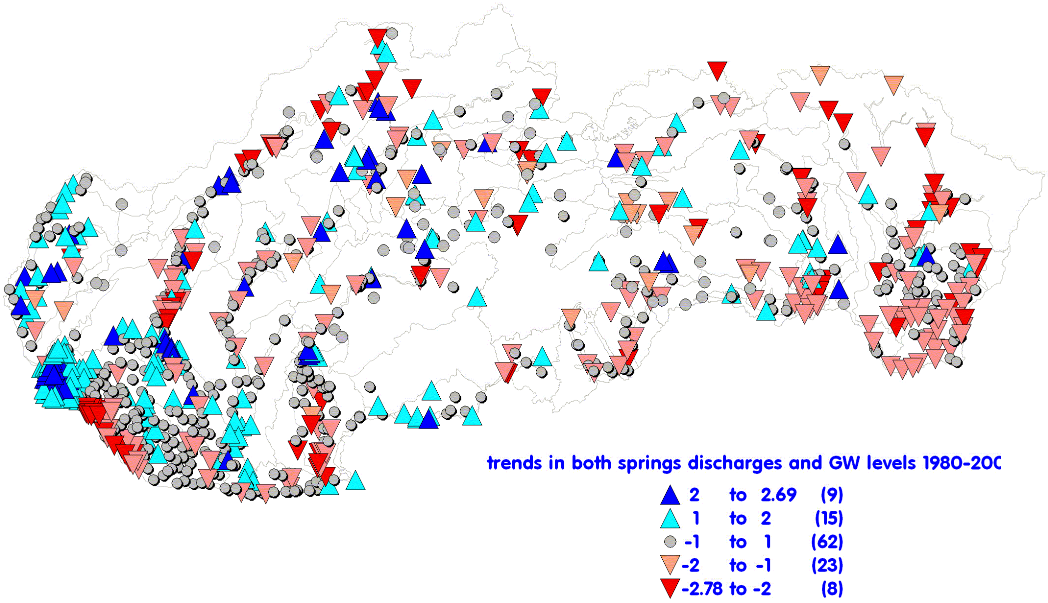


Figure 3: Long-term trends in both groundwater levels and springs' discharges in the period of 1980-2003.

According to the results of trend weights summation for individual pre-Quaternary groundwater bodies in Table 3, no pre-Quaternary groundwater body under quantitative risk was identified. One can see that the results derived from 116 springs + 4 pre-Quaternary wells are relatively regularly distributed throughout all categories, both showing trends of increase and decrease of discharge. Within individual groundwater bodies, both discharge increase and decrease was observed during last 24 years (1980 – 2003), so no additional groundwater body under quantitative risk was additionally identified as a consequence of discharge trend analyses.

Other situation can be found in the layer of Quaternary groundwater bodies. The monitoring network of piezometric levels in wells there has substantially larger population, counting 687 wells that could be linked to Quaternary groundwater bodies (115 wells from 806 that could be evaluated for groundwater level trends in the 1980 – 2003 period were localized in the smaller Quaternary alluvia connected with pre-Quaternary groundwater bodies, and 4 were screening pre-Quaternary aquifers).

For Quaternary groundwater bodies **SK1000200P** "Intergranular groundwater body of Quaternary sediments in the W part of the Danubian Basin in the Danube watershed area"; **SK1000300P** "Intergranular groundwater body of Quaternary sediments of the Danubian Basin in the Váh watershed area" and **SK1000400P** "Intergranular groundwater body of Quaternary sediments of rivers Váh, Nitra and their tributaries in the S part of the Váh watershed area", as shown in the Table 2, increasing (positive) trends were received in the process of trend weights summation. This means that groundwater levels during the period of 1980 – 2003 were rising in the ranges greater than standard deviation in substantially more wells than for that with levels decrease.

On the other hand, for Quaternary groundwater levels in groundwater bodies of **SK1001200P** and **SK1001500P** ("Intergranular groundwater body of Quaternary sediments of the Hornád watershed area" and "Intergranular groundwater body of Quaternary sediments of the S part of Bodrog watershed area"), both of them situated on the east of the country, more decreasing trends than increasing ones were detected. For the **SK1001200P** groundwater body "Intergranular groundwater body of Quaternary sediments of the Hornád watershed area", where 44 wells were observed during the 1980 – 2003 period, only 5 of them showed piezometric level increase greater than $1*\boldsymbol{\sigma}$ (standard deviation) and not a single well was with increasing trend greater than $2*\boldsymbol{\sigma}$, while decreasing trends greater than $1*\boldsymbol{\sigma}$ were found in 13 wells and even greater than $2*\boldsymbol{\sigma}$ in 7 monitoring wells. For the **SK1001500P** groundwater body "Intergranular groundwater body of Quaternary sediments of the S part of Bodrog watershed area", 76 wells were observed during the 1980 – 2003 period. Only 3 of them showed piezometric level increase greater than $1*\boldsymbol{\sigma}$ (standard deviation) and not a single well was with increasing trend greater than $2*\boldsymbol{\sigma}$. Decreasing trends greater than $1*\boldsymbol{\sigma}$ were found in 28 wells and even greater than $2*\boldsymbol{\sigma}$ in 6 monitoring wells.

Because of these results, we assume that Quaternary groundwater bodies SK1001200P "Intergranular groundwater body of Quaternary sediments of the Hornád watershed area" and SK1001500P "Intergranular groundwater body of Quaternary sediments of the S part of Bodrog watershed area" should be pointed out as being under quantitative risk.

Further characterization of qualitative risk

Figure 4 Measured nitrate concentrations in Quaternary groundwater bodies

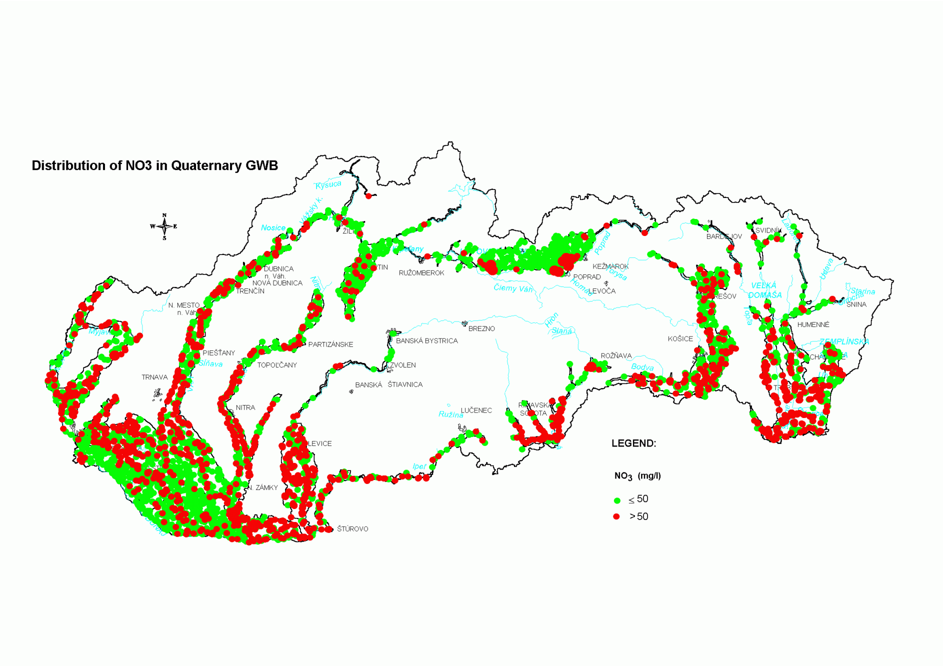
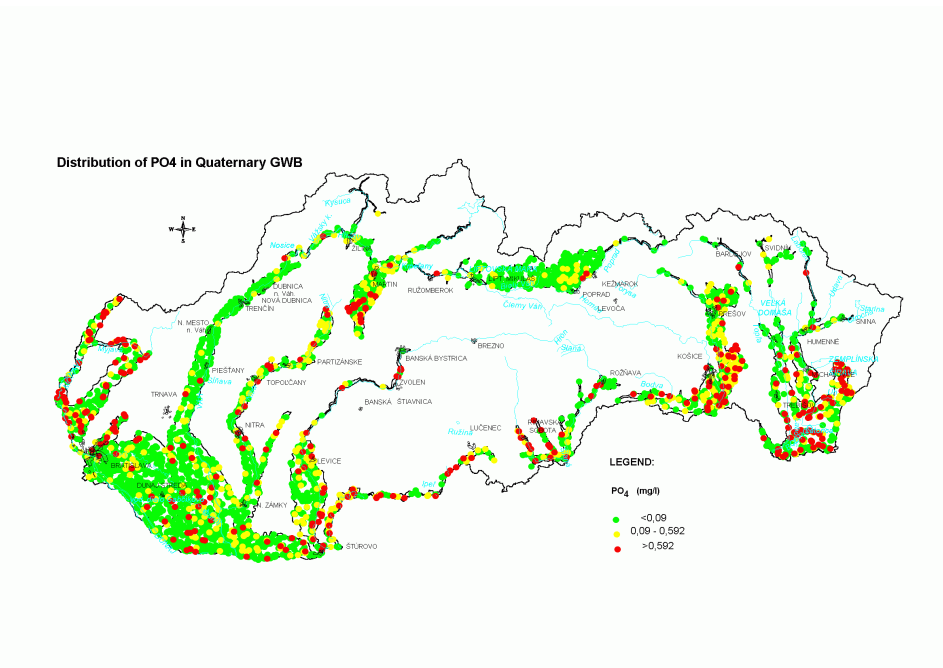


Figure 5 Measured phosphate concentrations in Quaternary groundwater bodies



CHARACTERISATION OF OVERLYING STRATA
SOIL COVER IN INDIVIDUAL GROUNDWATER BODIES

Methodology

To evaluate soil depth, soil permeability and number of pores two complex parameters of soils were used:
soil permeability potential (soil permeability potential) as a function of soil texture, stoniness and soil depth
soil water retention potential (soil water retention potential) as a function of soil water retention capacity and soil depth

Four-class categorisation was used to express the rate of protection potential of soil according to possible negative influence of surface contamination to groundwater (A – very high, B - high, C – medium, D – low) for the two input parameters. The overall protection potential of soil was evaluated also in four categories as "quite low"; "lowered"; "higher" and "quite high" for the whole groundwater body. The results are listed in *Table 1* at the end of the text.

SK200010FK - Fissure and karst-fissure groundwater body of the Pezinské Karpaty Mts. in the watershed area of Dunaj

The evaluated area (e.i agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 12,11% of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area EA creates small irregularly distributed patterns which occur mainly in NW and S parts of area. Most of EA soil cover is represented by soils with high (83,63%) or very high (13,54%) soil permeability potential, high (85,07%) or very high (0,01%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (2,82%) or very weakly (0,01%) soil permeability potential, low (14,92%) soil water retention potential. In general, groundwater body SK200010FK shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK2000200P - Intergranular groundwater body of the Vienna Basin in the watershed area of Dunaj

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 57,57% of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which occur mainly in N, W, SW and S parts of area. Most of EA soil cover is represented by soils with high (43,20%) or very high (10,52%) soil permeability potential, high (41,70%) or very high (8,84%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (38,07%) or very weakly (8,21%) soil permeability potential, low (44,83%) or medium (4,63%) soil water retention potential. In general, groundwater body SK2000200P shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK200030FK - Fissure and karst-fissure groundwater body of the Pezinské Karpaty Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 18,86% of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact irregularly distributed patterns which cover SE and S parts of area. Most of EA soil cover is represented by soils with very high (45,50%) or high (45,03%) soil permeability potential, high (52,06%) or very high (1,35%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (8,73%) or very weakly (0,74%) soil permeability potential, low (43,59%) or medium (3,0%) soil water retention potential. In general, groundwater body SK200030FK shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK2000400P - Intergranular groundwater body of the W part of the Vienna Basin in the watershed area of Dunaj

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 44,36 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in N, NE, E and SW parts of area. Most of EA soil cover is represented by soils with high (46,55%) or very high (19,36%) soil permeability potential, high (67,61%) or very high (13,13%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (27,55%) or very weakly (6,55%) soil permeability potential, low (13,51%) or medium (5,75%) soil water retention potential. In general, groundwater body SK2000400P shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK2000500P - Intergranular groundwater body of the Pannonian Basin in the watershed area of Dunaj

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 66,75 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (46,56%) or very weakly (18,59%) soil permeability potential, high (48,58%) or very high (18,59%) soil water retention potential. Minority of EA soil cover is represented by soils with high (32,49%) or very high (2,37%) soil permeability potential, low (22,44%) or medium (10,38%) soil water retention potential. In general, groundwater body SK2000500P shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK200060KF - Dominant karst-fissure groundwater body of the Pezinské Karpaty Mts. in the watershed area of Dunaj

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 22,86 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in NW and SW parts of area. Most of EA soil cover is represented by soils with high (70,19%) or very high (10,94%) soil permeability potential, high (90,56%) or very high (2,68%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (18,54%) or very weakly (0,33%) soil permeability potential, medium (5,81%) or low (0,95%) soil water retention potential. In general, groundwater body SK200060KF shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK2000700F - Fissure groundwater body in the W part of the flysh belt in the watershed area of Dunaj

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 63,55 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with weakly (53,70%) or very weakly (6,34%) soil permeability potential. Minority of EA soil cover is represented by soils with high (37,32%) or very high (2,64%) soil permeability potential, medium (1,80%) or low (0,28%) soil water retention potential. In general, groundwater body SK2000700F shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK200080KF - Dominant karst-fissure groundwater body of Pezinské, Brezovské and Čachtické Karpaty Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 27,63 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in NE, SE and S parts of area. Most of EA soil cover is represented by soils with weakly (51,66%) or very weakly (2,68%) soil permeability potential, high (93,48%) or very high (4,18%) soil water retention potential. Minority of EA soil cover is represented by soils with high (31,47%) or very high (14,19%) soil permeability potential, medium (2,04%) or low (0,30%) soil water retention potential. In general, groundwater body SK200080KF shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK200090FK - Fissure groundwater body of the Myjavská pahorkatia hills in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 66,24 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with high (52,01%) or very high (8,84%) soil permeability potential, high (94,19%) or very high (5,26%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (36,80%) or very weakly (2,35%) soil permeability potential, low (0,55%) soil water retention potential. In general, groundwater body SK200090FK shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK2001000P - Intergranular groundwater body of the Pannonian Basin and its folders in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 83,38 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (63,93%) or very weakly (21,07%) soil permeability potential, high (68,83%) or very high (21,41%) soil water retention potential. Minority of EA soil cover is represented by soils with high (11,13%) or very high (3,87%) soil permeability potential, medium (5,35%) or low (4,41%) soil water retention potential. In general, groundwater body SK2001000P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK200110KF - Dominant karst-fissure groundwater body of Považský Inovec Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 32,01 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in SW, W, S and NE parts of area. Most of EA soil cover is represented by soils with weakly (50,85%) or very weakly (0,59%) soil permeability potential, high (97,88%) or very high (0,85%) soil water retention potential. Minority of EA soil cover is represented by soils with high (42,52%) or very high (6,03%) soil permeability potential, low (0,81%) or medium (0,45%) soil water retention potential. In general, groundwater body SK200110KF shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK200120FK - Fissure and karst-fissure groundwater body of the Považský Inovec Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 33,67 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in NW, N and S parts of area. Most of EA soil cover is represented by soils with high (40,27%) or very high (16,23%) soil permeability potential, high (90,56%) or very high (6,93%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (37,37%) or very weakly (6,13%) soil permeability potential. In general, groundwater body SK200120FK shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK2001300P - Intergranular groundwater body of the Bánovce Basin and its folders in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 75,88 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (75,38%) or very weakly (15,79%) soil permeability potential, high (81,12%) or very high (17,06%) soil water retention potential. Minority of EA soil cover is represented by soils with high (7,69%) or very high (1,14%) soil permeability potential, medium (1,67%) or low (0,15%) soil water retention potential. In general, groundwater body SK2001300P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK200140KF - Dominant karst-fissure groundwater body of the Strážovské vrchy and Lúčanská Malá Fatra Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 27,06 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with high (38,61%) or very high (16,70%) soil permeability potential. Minority of EA soil cover is represented by soils with weakly (35,40%) or very weakly (9,30%) soil permeability potential, medium (6,77%) or low (0,40%) soil water retention potential. In general, groundwater body SK200140KF shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK200150FP - Fissure and karst-fissure groundwater body od the Tribeč Mts.

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 27,51 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in N, NE, SE and S parts of area. Most of EA soil cover is represented by soils with weakly (47,44%) or very weakly (8,38%) soil permeability potential. Minority of EA soil cover is represented by soils with high (31,43%) or very high (12,76%) soil permeability potential, medium (8,61%) or low (0,21%) soil water retention potential. In general, groundwater body SK200150FP shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK200160FK - Fissure and karst-fissure groundwater body of the Strážovské vrchy Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 32,51 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in SW, S and NW parts of area. Most of EA soil cover is represented by soils with high (42,71%) or very high (31,10%) soil permeability potential, high (49,22%) or very high (17,48%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (23,24%) or very weakly (1,95%) soil permeability potential, medium (17,11%) or low (16,19%) soil water retention potential. In general, groundwater body SK200160FK shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK200170FP - Fissure and intergranular groundwater body of the Horná Nitra Basin neovolcanoes and Tertiary sediments in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 53,41 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact irregularly distributed patterns which cover N, W and SW parts of area. Most of EA soil cover is represented by soils with weakly (61,95%) or very weakly (5,44%) soil permeability potential, high (78,31%) or very high (5,85%) soil water retention potential. Minority of EA soil cover is represented by soils with high (22,76%) or very high (9,86%) soil permeability potential, medium (14,03%) or low (1,81%) soil water retention potential. In general, groundwater body SK200170FP shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK2001800F - Fissure groundwater body of the W part of flysch belt and podtatranská skupina group in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 46,98 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with high (42,74%) or very high (27,21%) soil permeability potential, high (57,87%) or very high (15,02%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (25,48%) or very weakly (4,57%) soil permeability potential, medium (23,74%) or low (3,36%) soil water retention potential. In general, groundwater body SK2001800F shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK200190FK - Fissure and karst-fissure groundwater body of the Žiar Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 43,64 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact irregularly distributed patterns which cover SW and S parts of area. Most of EA soil cover is represented by soils with high (47,13%) or very high (24,16%) soil permeability potential, high (46,26%) or very high (12,67%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (26,63%) or very weakly (2,08%) soil permeability potential, medium (39,27%) or low (1,80%) soil water retention potential. In general, groundwater body SK200190FK shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK200200FP - Fissure and intergranular groundwater body of the Vtáčnik and Kremnické vrchy Mts. neovolcanoes in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 26,16 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in NW, W and S parts of area. Most of EA soil cover is represented by soils with high (51,23%) or very high (40,19%) soil permeability potential, high (52,69%) or very high (1,48%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (8,48%) or very weakly (0,10%) soil permeability potential, medium (45,78%) or low (0,06%) soil water retention potential. In general, groundwater body SK200200FP shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK2002100P - Intergranular groundwater body of the Turčianska kotlina Basin in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 71,34 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with weakly (40,18%) or very weakly (20,86%) soil permeability potential. Minority of EA soil cover is represented by soils with very high (24,68%) or high (14,27%) soil permeability potential, medium (17,00%) or low (2,45%) soil water retention potential. In general, groundwater body SK2002100P shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK200220FP - Fissure and intergranular groundwater body of the N part of Central Slovakian Neovolcanoes

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 40,70 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with high (35,74%) or very high (29,97%) soil permeability potential, high (69,63%) or very high (5,46%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (29,86%) or very weakly (4,43%) soil permeability potential, medium (23,14%) or low (1,77%) soil water retention potential. In general, groundwater body SK200220FP shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK2002300P - Intergranular groundwater body of the Pannonian Basin and Ipeľská kotlina Basin in the watershed area of Hron

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 82,14 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (68,80%) or very weakly (22,29%) soil permeability potential, high (72,59%) or very high (24,16%) soil water retention potential. Minority of EA soil cover is represented by soils with high (7,59%) or very high (1,31%) soil permeability potential, low (1,63%) or medium (1,62%) soil water retention potential. In general, groundwater body SK2002300P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK200240FK - Fissure and karst-fissure groundwater body of the Malá Fatra Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 14,04 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in S, SE, NE and N parts of area. Most of EA soil cover is represented by soils with high (59,03%) or very high (28,01%) soil permeability potential, high (64,88%) or very high (9,67%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (12,28%) or very weakly (0,67%) soil permeability potential, medium (15,50%) or low (9,94%) soil water retention potential. In general, groundwater body SK200240FK shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK200250KF - Dominant karst-fissure groundwater body of the Veľká Fatra Mts. in the watershed area of Hron

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 25,96 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in N, NE and S parts of area. Most of EA soil cover is represented by soils with high (61,61%) or very high (30,47%) soil permeability potential, high (68,93%) or very high (6,21%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (7,72%) or very weakly (0,21%) soil permeability potential, medium (22,24%) or low (2,62%) soil water retention potential. In general, groundwater body SK200250KF shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK200260FP - Fissure and intergranular groundwater body of the S part of Central Slovakian Neovolcanoes in the watershed area of Hron

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 54,74 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with high (30,52%) or very high (22,71%) soil permeability potential, high (73,51%) or very high (18,68%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (31,41%) or very weakly (15,36%) soil permeability potential, medium (7,58%) or low (0,23%) soil water retention potential. In general, groundwater body SK200260FP shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK200270KF - Dominant karst-fissure groundwater body of the Veľká Fatra, Chočské

vrchy and Západné Tatry Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 19,92 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in N, NW, S and SE parts of area. Most of EA soil cover is represented by soils with high (37,52%) or very high (15,64%) soil permeability potential, high (47,93%) or very high (42,29%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (41,12%) or very weakly (5,72%) soil permeability potential. In general, groundwater body SK200270KF shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK200280FK - Fissure and karst-fissure groundwater body of the Nízke Tatry and Slovenské Rudohorie Mts. in the watershed area of Hron

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 35,29 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with very high (58,40%) or high (22,95%) soil permeability potential, low (31,72%) or medium (28,78%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (17,53%) or very weakly (1,12%) soil permeability potential, high (36,43%) or very high (3,08%) soil water retention potential. In general, groundwater body SK200280FK shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK200290FK - Fissure and karst-fissure groundwater body of the S part of Nízke Tatry Mts. in the watershed area of Hron

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 28,04 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in N, NW, S and SE parts of area. Most of EA soil cover is represented by soils with very high (52,63%) or high (32,28%) soil permeability potential, high (49,93%) or very high (7,20%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (14,93%) or very weakly (0,15%) soil permeability potential, medium (30,22%) or low (12,65%) soil water retention potential. In general, groundwater body SK200290FK shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK200300FK - Fissure and karst-fissure groundwater body of the NW of Nízke Tatry Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 13,52 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in N, NW and W parts of area. Most of EA soil cover is represented by soils with very high (43,33%) or high (25,17%) soil permeability potential, high (35,25%) or very high (24,76%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (29,52%) or very weakly (1,99%) soil permeability potential, medium (30,34%) or low (9,65%) soil water retention potential. In general, groundwater body SK200300FK shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK2003100P - Intergranular groundwater body of the Lučenská kotlina Basin and W part of Cerová vrchovina hills in the watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 65,39 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (64,07%) or very weakly (16,95%) soil permeability potential, high (74,56%) or very high (18,67%) soil water retention potential. Minority of EA soil cover is represented by soils with high (15,98%) or very high (3,00%) soil permeability potential, medium (6,42%) or low (0,35%) soil water retention potential. In general, groundwater body SK2003100P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK2003200P - Intergranular groundwater body of the Oravská kotlina Basin in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 46,04 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact irregularly distributed patterns which cover S, SE and N parts of area. Most of EA soil cover is represented by soils with high (66,06%) or very high (16,19%) soil permeability potential, medium (69,71%) or low (0,11%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (17,17%) or very weakly (0,57%) soil permeability potential, high (29,60%) or very high (0,57%) soil water retention potential. In general, groundwater body SK2003200P shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK2003300F - Fissure groundwater body of the podtatranská skupina group in the Liptovská kotlina Basin in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 71,97 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with high (30,11%) or very high (27,39%) soil permeability potential, high (54,05%) or very high (14,12%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (35,04%) or very weakly (7,46%) soil permeability potential, medium (26,62%) or low (5,21%) soil water retention potential. In general, groundwater body SK2003300F shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK200340KF - Dominant karst-fissure groundwater body of the NE of Nízke Tatry Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 22,99 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in N and NE parts of area. Most of EA soil cover is represented by soils with high (42,35%) or very high (35,31%) soil permeability potential, high (61,32%) or very high (3,90%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (20,23%) or very weakly (2,11%) soil permeability potential, medium (29,49%) or low (5,30%) soil water retention potential. In general, groundwater body SK200340KF shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK200350FK - Fissure and karst-fissure groundwater body of the Tatry Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 1,09 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur in middle part of area. Most of EA soil cover is represented by soils with very high (90,98%) or high (7,73%) soil permeability potential, medium (73,67%) or low (11,29%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (1,29%) soil permeability potential, high (14,46%) or very high (0,58%) soil water retention potential. In general, groundwater body SK200350FK shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK200360FK - Fissure and karst-fissure groundwater body of the NE of Nízke Tatry Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 14,96 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in W, S and SE parts of area. Most of EA soil cover is represented by soils with very high (73,44%) or high (22,00%) soil permeability potential, low (34,66%) or medium (29,41%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (4,34%) or very weakly (0,22%) soil permeability potential, high (33,02%) or very high (2,90%) soil water retention potential. In general, groundwater body SK200360FK shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK2003700P - Intergranular groundwater body of the Rimavská kotlina Basin, Oždianska pahorkatina hills and E part of Cerová vrchovina hills of the watershed area of Hron

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 69,38 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with weakly (43,50%) or very weakly (32,09%) soil permeability potential, high (50,87%) or very high (37,14%) soil water retention potential. Minority of EA soil cover is represented by soils with high (17,34%) or very high (7,06%) soil permeability potential, medium (11,60%) or low (0,39%) soil water retention potential. In general, groundwater body SK2003700P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK200380FP - Fissure and intergranular groundwater body of the neovolcanoes of Pokoradzská tabuľa Plateau

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 46,52 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact irregularly distributed patterns which cover in N, NE and NW parts of area. Most of EA soil cover is represented by soils with weakly (58,56%) or very weakly (13,71%) soil permeability potential. Minority of EA soil cover is represented by soils with high (18,33%) or very high (9,41%) soil permeability potential, medium (4,73%) or low (0,05%) soil water retention potential. In general, groundwater body

SK200380FP shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK200390KF - Dominant karst-fissure groundwater body of the Muránska Planina Plateau in the watershed area of Hron

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 25,10 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in N, SW and S parts of area. Most of EA soil cover is represented by soils with very high (70,20%) or very high (19,68%) soil permeability potential, low (37,72%) or medium (33,88%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (9,56%) or very weakly (0,56%) soil permeability potential, high (25,78%) or very low (2,62%) soil water retention potential. In general, groundwater body SK200390KF shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK2004000P - Intergranular groundwater body of the Valická pahorkatina hills in the watershed area of Hron

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 77,39 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (55,94%) or very weakly (37,16%) soil permeability potential, high (55,70%) or very high (43,56%) soil water retention potential. Minority of EA soil cover is represented by soils with high (5,08%) or very high (1,82%) soil permeability potential, medium (0,74%) soil water retention potential. In general, groundwater body SK2004000P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK200410KF - Fissure and karst-fissure groundwater body of the E of Nízke Tatry Mts. in the watershed area of Váh

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 18,40 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in N and S parts of area. Most of EA soil cover is represented by soils with very high (80,22%) or high (18,45%) soil permeability potential, medium (37,51%) or low (28,55%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (1,34%) soil permeability potential, high (33,94%) soil water retention potential. In general, groundwater body SK200410KF shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK200420FK - Fissure and karst-fissure groundwater body of the Kozie chrbty Mts. in the watershed area of Poprad and Dunajec

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 44,39 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in W, NW, SW and E parts of area. Most of EA soil cover is represented by soils with very high (36,66%) or high (28,49%) soil permeability potential, high (57,89%) or very high (6,52%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (32,60%) or very weakly (2,25%) soil permeability potential, medium (24,66%) or low (10,92%) soil water retention potential. In general, groundwater body SK200420FK shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK200430FK - Fissure groundwater body of the Nízke Tatry and Kozie chrbty Mts. in the watershed area of Hornád

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 21,49 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in W, SW and E parts of area. Most of EA soil cover is represented by soils with very high (75,36%) or high (17,40%) soil permeability potential. Minority of EA soil cover is represented by soils with weakly (6,19%) or very weakly (1,05%) soil permeability potential, high (25,64%) or very high (4,24%) soil water retention potential. In general, groundwater body SK200430FK shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK200440KF - Dominant karst-fissure groundwater body of the Tatry Mts. in the watershed area of Poprad and Dunajec

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 1,37 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in N part of area. Most of EA soil cover is represented by soils with high (51,06%) or very high (31,41%) soil permeability potential, high (78,60%) or very high (17,53%) WR. Minority of EA soil cover is represented by soils with weakly (17,53%) soil permeability potential, medium (3,87%) soil water retention potential. In general, groundwater body SK200440KF shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK2004500P - Intergranular groundwater body of the Gemerská pahorkatina hills in the watershed area of Hron

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 52,93 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact irregularly distributed patterns which cover S, NW and NE parts of area. Most of EA soil cover is represented by soils with very weakly (49,11%) or weakly (38,57%) soil permeability potential, very high (59,59%) or high (39,60%) soil water retention potential. Minority of EA soil cover is represented by soils with high (10,42%) or very high (1,89%) soil permeability potential, medium (0,81%) soil water retention potential. In general, groundwater body SK2004500P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK200460KF - Dominant karst-fissure groundwater body of the Slovenský Raj and Galmus Mts. in the watershed area of Hornád

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 13,24 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in E, SW and NW parts of area. Most of EA soil cover is represented by soils with very high (63,59%) or high (32,19%) soil permeability potential, high (58,48%) or very high

(1,09%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (4,10%) or very weakly (0,12%) soil permeability potential, medium (33,94%) or low (6,49%) soil water retention potential. In general, groundwater body SK200460KF shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK2004700F - Fissure groundwater body of the flysch belt and podtatranská skupina group in the watershed area of Poprad and Dunajec

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 46,71 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which occur mainly in NW, N, NE and S parts of area. Most of EA soil cover is represented by soils with very high (37,36%) or high (33,65%) soil permeability potential, high (52,25%) or very high (18,97%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (24,05%) or very weakly (4,94%) soil permeability potential, medium (26,08%) or low (2,70%) soil water retention potential. In general, groundwater body SK2004700F shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK200480KF - Dominant karst-fissure groundwater body of the Slovenský Kras Mts. in the watershed area of Hron and Hornád

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 34,55 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with very high (32,93%) or high (26,93%) soil permeability potential, high (72,28%) or very high (21,54%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (29,94%) or very weakly (10,20%) soil permeability potential, medium (5,98%) or low (0,19%) soil water retention potential. In general, groundwater body SK200480KF shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK2004900F - Fissure groundwater body of the podtatranská skupina group and flysch belt in the watershed area of Hornád

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 56,64 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with very high (32,28%) or high (30,83%) soil permeability potential, high (49,12%) or very high (22,35%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (31,60%) or very weakly (5,29%) soil permeability potential, medium (25,26%) or low (3,26%) soil water retention potential. In general, groundwater body SK2004900F shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK200500FK - Fissure and karst-fissure groundwater body of the Slovenské Rudohorie Mts. in the watershed area of Hornád

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 17,99 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in N, S and SE parts of area. Most of EA soil cover is represented by soils with very high (52,56%) or high (41,16%) soil permeability potential, high (64,02%) or very high (1,10%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (5,44%) or very weakly (0,84%) soil permeability potential, medium (32,20%) or low (2,69%) soil water retention potential. In general, groundwater body SK200500FK shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK200510KF - Dominant karst-fissure groundwater body of the Branisko and Čierna Hora Mts. in the watershed area of Hornád

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 28,58 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in NE, E and SE parts of area. Most of EA soil cover is represented by soils with very high (50,41%) or high (38,12%) soil permeability potential, high (53,97%) or very high (4,88%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (9,69%) or very weakly (1,77%) soil permeability potential, medium (36,86%) or low (4,29%) soil water retention potential. In general, groundwater body SK200510KF shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK2005200P - Intergranular groundwater body of the Abovská pahorkatina hills in the watershed area of Hornád

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 77,15 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (64,28%) or very weakly (18,13%) soil permeability potential, high (76,69%) or very high (21,35%) soil water retention potential. Minority of EA soil cover is represented by soils with high (12,23%) or very high (5,36%) soil permeability potential, medium (1,96%) soil water retention potential. In general, groundwater body SK2005200P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK2005300P - Intergranular groundwater body of the Košická kotlina Basin in the watershed area of Hornád

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 71,13 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with weakly (51,49%) or very weakly (22,24%) soil permeability potential, high (66,38%) or very high (25,55%) soil water retention potential. Minority of EA soil cover is represented by soils with high (15,49%) or very high (10,78%) soil permeability potential, medium (7,36%) or low (0,71%) soil water retention potential. In general, groundwater body SK2005300P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK200540FP - Fissure and intergranular groundwater body of the Slanské vrchy Mts. neovolcanoes in the watershed area of Hornád

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 27,67 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in NW, W and SW parts of area. Most of EA soil cover is represented by soils with very high (52,10%) or high (26,98%) soil permeability potential, high (76,24%) or very high (10,69%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (15,97%) or very weakly (4,96%) soil permeability potential, medium (12,60%) or low (0,47%) soil water retention potential. In general, groundwater body SK200540FP shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK200550FP - Fissure and intergranular groundwater body of the Slanské vrchy Mts. neovolcanoes in the watershed area of Bodrog

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 22,32 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in N, NW and S parts of area. Most of EA soil cover is represented by soils with high (31,16%) or very high (23,63%) soil permeability potential, high (67,86%) or very high (29,03%) soil water retention potential, low (62,14%) SOC and moderate (93,15%) SSP. Minority of EA soil cover is represented by soils with very weakly (22,91%) or weakly (22,30%) soil permeability potential, medium (2,85%) or low (0,25%) soil water retention potential. In general, groundwater body SK200550FP shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK200560FK - Fissure and karst-fissure groundwater body of the "Zemplín island" Mts. in the watershed area of Bodrog

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 50,51 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact irregularly distributed patterns which cover W, SW and S parts of area. Most of EA soil cover is represented by soils with very high (35,30%) or high (28,56%) soil permeability potential. Minority of EA soil cover is represented by soils with weakly (25,77%) or very weakly (10,37%) soil permeability potential, medium (21,46%) or low (0,77%) soil water retention potential. In general, groundwater body SK200560FK shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK2005700F - Fissure groundwater body of the flysch belt and podtatranská skupina group in the watershed area of Bodrog

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 43,28 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with high (39,26%) or very high (28,89%) soil permeability potential, high (56,39%) or very high (16,42%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (27,36%) or very weakly (4,50%) soil permeability potential, medium (25,24%) or low (1,95%) soil water retention potential. In general, groundwater body SK2005700F shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK2005800P - Intergranular groundwater body of the East Slovakian Basin in the watershed area of Bodrog

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 81,31 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with very weakly (44,65%) or weakly (42,50%) soil permeability potential, high (45,85%) or very high (45,32%) soil water retention potential. Minority of EA soil cover is represented by soils with high (10,66%) or very high (2,19%) soil permeability potential, medium (5,31%) or low (3,52%) soil water retention potential. In general, groundwater body SK2005800P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK200590FP - Fissure and intergranular groundwater body of Vihorlat Mts. neovolcanoes in the watershed area of Bodrog

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 17,64 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which cover SW and S parts of area. Most of EA soil cover is represented by soils with high (30,78%) or very high (24,98%) soil permeability potential, high (92,95%) or very high (2,08%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (42,85%) or very weakly (1,40%) soil permeability potential, medium (4,97%) soil water retention potential. In general, groundwater body SK200590FP shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK1000100P - Intergranular groundwater body of the Vienna Basin Quaternary sediments in the Danube watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 31,42 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which occur mainly in NE, E, S and SW parts of area. Most of EA soil cover is represented by soils with high (40,47%) or very high (20,27%) soil permeability potential, low (46,37%) or medium (7,35%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (27,70%) or very weakly (11,55%) soil permeability potential, high (34,73%) or very high (11,55%) soil water retention potential. In general, groundwater body SK1000100P shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK1000200P - Intergranular groundwater body of Quaternary sediments in the W part of the Danubian Basin in the Danube watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 55,05 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (45,06%) or very weakly (27,30%) soil permeability potential, high (47,85%) or very high (27,30%) soil water retention potential. Minority of EA soil cover is represented by soils with high (23,38%) or very high (4,26%) soil permeability potential, medium (15,41%) or low (9,44%) soil water retention potential. In general, groundwater body SK1000200P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK1000300P - Intergranular groundwater body of Quaternary sediments of the Danubian Basin in the Váh watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 82,53 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (50,40%) or very weakly (20,38%) soil permeability potential, high (61,16%) or very high (20,43%) soil water retention potential. Minority of EA soil cover is represented by soils with high (20,09%) or very high (9,13%) soil permeability potential, medium (11,17%) or low (7,24%) soil water retention potential. In general, groundwater body SK1000300P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK1000400P - Intergranular groundwater body of Quaternary sediments of rivers Váh, Nitra and their tributaries in the S part of the Váh watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 75,13 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with weakly (37,98%) or very weakly (35,20%) soil permeability potential, high (46,41%) or very high (36,53%) soil water retention potential. Minority of EA soil cover is represented by soils with very high (13,62%) or high (13,20%) soil permeability potential, medium (11,50%) or low (5,56%) soil water retention potential. In general, groundwater body SK1000400P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK1000500P - Intergranular groundwater body of Quaternary sediments of the Váh river and its tributaries in the N part of the Váh watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 75,13 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with weakly (37,98%) or very weakly (35,20%) soil permeability potential, high (46,41%) or very high (36,53%) soil water retention potential. Minority of EA soil cover is represented by soils with very high (13,62%) or high (13,20%) soil permeability potential, medium (11,50%) or low (5,56%) soil water retention potential. In general, groundwater body SK1000500P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK1000600P - Intergranular groundwater body of Quaternary sediments in the E part of the Danubian Basin in the Danube watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 79,66 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (47,68%) or very weakly (12,56%) soil permeability potential, high (49,00%) or very high (12,57%) soil water retention potential. Minority of EA soil cover is represented by soils with high (38,69%) or very high (1,06%) soil permeability potential, low (31,52%) or medium (6,91%) soil water retention potential. In general, groundwater body SK1000600P shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK1000700P - Intergranular groundwater body of Quaternary sediments of the Hron river in the Hron watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 85,44 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with high (83,63%) or very high (13,54%) soil permeability potential, high (85,07%) or very high (0,01%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (2,82%) or very weakly (0,01%) soil permeability potential, low (14,92%) soil water retention potential. In general, groundwater body SK1000700P shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK1000800P - Intergranular groundwater body of Quaternary sediments of the Ipeľ river in the Hron watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 86,69 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with high (43,20%) or very high (10,52%) soil permeability potential, high (41,70%) or very high (8,84%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (38,07%) or very weakly (8,21%) soil permeability potential, low (44,83%) or medium (4,63%) soil water retention potential. In general, groundwater body SK1000800P shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK1000900P - Intergranular groundwater body of Quaternary sediments of the Rimava river and its tributaries in the Hron watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 87,42 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with very high (45,50%) or high (45,03%) soil permeability potential, high (52,06%) or very high (1,35%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (8,73%) or very weakly (0,74%) soil permeability potential, low (43,59%) or medium (3,00%) soil water retention potential. In general, groundwater body SK1000900P shows quite low potential of soil according to possible negative influence of surface contamination to groundwater.

SK1001000P - Intergranular groundwater body of Quaternary sediments of the Poprad and Dunajec watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 48,06 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small irregularly distributed patterns which occur mainly in S, SE and E parts of area. Most of EA soil cover is represented by soils with high (46,55%) or very high (19,36%) soil permeability potential, high (67,61%) or very high (13,13%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (27,55%) or very weakly (6,55%) soil permeability potential, low (13,51%) or medium (5,75%) soil water retention potential. In general, groundwater body SK1001000P shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK1001100P - Intergranular groundwater body of Quaternary sediments of the Slaná river and its tributaries in the Hron watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 79,46 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (46,56%) or very weakly (18,59%) soil permeability potential, high (48,58%) or very high (18,59%) soil water retention potential. Minority of EA soil cover is represented by soils with high (32,49%) or very high (2,37%) soil permeability potential, low (22,44%) or medium (10,38%) soil water retention potential. In general, groundwater body SK1001100P shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK1001200P - Intergranular groundwater body of Quaternary sediments of the Hornád watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 72,92 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with high (70,19%) or very high (10,94%) soil permeability potential, high (90,56%) or very high (2,68%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (18,54%) or very weakly (0,33%) soil permeability potential, medium (5,81%) or low (0,95%) soil water retention potential. In general, groundwater body SK1001200P shows lowered potential of soil according to possible negative influence of surface contamination to groundwater.

SK1001300P - Intergranular groundwater body of Quaternary sediments of the Topľa river in the Bodrog watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 66,26 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (53,70%) or very weakly (6,34%) soil permeability potential, high (58,70%) or very high (39,21%) soil water retention potential. Minority of EA soil cover is represented by soils with high (37,32%) or very high (2,64%) soil permeability potential, medium (1,80%) or low (0,28%) soil water retention potential. In general, groundwater body SK1001300P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

SK1001400P - Intergranular groundwater body of Quaternary sediments of the Ondava river in the Bodrog watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 67,26 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with weakly (51,56%) or very weakly (2,68%) soil permeability potential, high (93,48%) or very high (4,18%) soil water retention potential. Minority of EA soil cover is represented by soils with high (31,47%) or very high (14,19%) soil permeability potential, medium (2,04%) or low (0,30%) soil water retention potential. In general, groundwater body SK1001400P shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK1001500P - Intergranular groundwater body of Quaternary sediments of the S part of Bodrog watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 81,70 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates large and compact patterns which regularly cover whole area. Most of EA soil cover is represented by soils with high (52,01%) or very high (8,84%) soil permeability potential, high (94,19%) or very high (5,26%) soil water retention potential. Minority of EA soil cover is represented by soils with weakly (36,80%) or very weakly (2,35%) soil permeability potential, low (0,55%) soil water retention potential. In general, groundwater body SK1001500P shows higher potential of soil according to possible negative influence of surface contamination to groundwater.

SK1001600P - Intergranular groundwater body of Quaternary sediments of the Laborec river in the Bodrog watershed area

The evaluated area (EA, e.i. agricultural land including arable land, grassland, pastures and permanent crops plantations) shares 60,15 % of total groundwater body area, rest of groundwater body area land cover is represented by forests, semi-natural land, surface water tables and artificial surfaces. Within the groundwater body area, evaluated area creates small regularly distributed patterns which cover whole area. Most of EA soil cover is represented by soils with weakly (63,93%) or very weakly (21,07%) soil permeability potential, high (68,83%) or very high (21,41%) soil water retention potential. Minority of EA soil cover is represented by soils with high (11,13%) or very high (3,87%) soil permeability potential, medium (5,35%) or low (4,41%) soil water retention potential. In general, groundwater body SK1001600P shows quite high potential of soil according to possible negative influence of surface contamination to groundwater.

Table 1: Overall values of total soil protection potential in individual groundwater bodies

groundwater body ID	PARAMETER I soil permeability				PARAMETER II soil water retention				total soil protection potential estimate
	categories				categories				
	A	B	C	D	A	B	C	D	
SK200010FK	0,01	2,82	83,63	13,54	0,01	85,07	0,00	14,92	quite low
SK2000200P	8,21	38,07	43,20	10,52	8,84	41,70	4,63	44,83	lowered
SK200030FK	0,74	8,73	45,03	45,50	1,35	52,06	3,00	43,59	quite low
SK2000400P	6,55	27,55	46,55	19,36	13,13	67,61	5,75	13,51	lowered
SK2000500P	18,59	46,56	32,49	2,37	18,59	48,58	10,38	22,44	higher
SK200060KF	0,33	18,54	70,19	10,94	2,68	90,56	5,81	0,95	lowered
SK2000700F	6,34	53,70	37,32	2,64	39,21	58,70	1,80	0,28	quite high
SK200080KF	2,68	51,66	31,47	14,19	4,18	93,48	2,04	0,30	higher
SK200090FK	2,35	36,80	52,01	8,84	5,26	94,19	0,00	0,55	higher
SK2001000P	21,07	63,93	11,13	3,87	21,41	68,83	5,35	4,41	quite high
SK200110KF	0,59	50,85	42,52	6,03	0,85	97,88	0,45	0,81	higher
SK200120FK	6,13	37,37	40,27	16,23	6,93	90,56	1,07	1,43	higher
SK2001300P	15,79	75,38	7,69	1,14	17,06	81,12	1,67	0,15	quite high
SK200140KF	9,30	35,40	38,61	16,70	27,08	65,75	6,77	0,40	higher
SK200150FP	8,38	47,44	31,43	12,76	11,94	79,24	8,61	0,21	higher
SK200160FK	1,95	23,24	42,71	32,10	17,48	49,22	17,11	16,19	lowered
SK200170FP	5,44	61,95	22,76	9,86	5,85	78,31	14,03	1,81	quite high
SK2001800F	4,57	25,48	42,74	27,21	15,02	57,87	23,74	3,36	lowered
SK200190FK	2,08	26,63	47,13	24,16	12,67	46,26	39,27	1,80	lowered
SK200200FP	0,10	8,48	51,23	40,19	1,48	52,69	45,78	0,06	quite low
SK2002100P	20,86	40,18	14,27	24,68	29,13	51,43	17,00	2,45	higher
SK200220FP	4,43	29,86	35,74	29,97	5,46	69,63	23,14	1,77	lowered
SK2002300P	22,29	68,80	7,59	1,31	24,16	72,59	1,62	1,63	quite high
SK200240FK	0,67	12,28	59,03	28,01	9,67	64,88	15,50	9,94	quite low
SK200250KF	0,21	7,72	61,61	30,47	6,21	68,93	22,24	2,62	quite low
SK200260FP	15,36	31,41	30,52	22,71	18,68	73,51	7,58	0,23	higher
SK200270KF	5,72	41,12	37,52	15,64	42,29	47,93	8,78	1,01	higher
SK200280FK	1,12	17,53	22,95	58,40	3,08	36,43	28,78	31,72	quite low
SK200290FK	0,15	14,93	32,28	52,63	7,20	49,93	30,22	12,65	quite low
SK200300FK	1,99	29,52	25,17	43,33	24,76	35,25	30,34	9,65	lowered
SK2003100P	16,95	64,07	15,98	3,00	18,67	74,56	6,42	0,35	quite high
SK2003200P	0,57	17,17	66,06	16,19	0,57	29,60	69,71	0,11	quite low
SK2003300F	7,46	35,04	30,11	27,39	14,12	54,05	26,62	5,21	lowered
SK200340KF	2,11	20,23	42,35	35,31	3,90	61,32	29,49	5,30	quite low
SK200350FK	0,00	1,29	7,73	90,98	0,58	14,46	73,67	11,29	quite low
SK200360FK	0,22	4,34	22,00	73,44	2,90	33,02	29,41	34,66	quite low
SK2003700P	32,09	43,50	17,34	7,06	37,14	50,87	11,60	0,39	quite high
SK200380FP	13,71	58,56	18,33	9,41	22,61	72,60	4,73	0,05	quite high
SK200390KF	0,56	9,56	19,68	70,20	2,62	25,78	33,88	37,72	quite low
SK2004000P	37,16	55,94	5,08	1,82	43,56	55,70	0,74	0,00	quite high
SK200410KF	0,00	1,34	18,45	80,22	0,00	33,94	37,51	28,55	quite low

groundwater body ID	PARAMETER I soil permeability				PARAMETER II soil water retention				total soil protection potential estimate
	categories				categories				
	A	B	C	D	A	B	C	D	
SK200420FK	2,25	32,60	28,49	36,66	6,52	57,89	24,66	10,92	lowered
SK200430FK	1,05	6,19	17,40	75,36	4,24	25,64	52,78	17,34	quite low
SK200440KF	0,00	17,53	51,06	31,41	17,53	78,60	3,87	0,00	lowered
SK2004500P	49,11	38,57	10,42	1,89	59,59	39,60	0,81	0,00	quite high
SK200460KF	0,12	4,10	32,19	63,59	1,09	58,48	33,94	6,49	quite low
SK2004700F	4,94	24,05	33,65	37,36	18,97	52,25	26,08	2,70	lowered
SK200480KF	10,20	29,94	26,93	32,93	21,54	72,28	5,98	0,19	higher
SK2004900F	5,29	31,60	30,83	32,28	22,35	49,12	25,26	3,26	lowered
SK200500FK	0,84	5,44	41,16	52,56	1,10	64,02	32,20	2,69	quite low
SK200510KF	1,77	9,69	38,12	50,41	4,88	53,97	36,86	4,29	quite low
SK2005200P	18,13	64,28	12,23	5,36	21,35	76,69	1,96	0,00	quite high
SK2005300P	22,24	51,49	15,49	10,78	25,55	66,38	7,36	0,71	quite high
SK200540FP	4,96	15,97	26,98	52,10	10,69	76,24	12,60	0,47	lowered
SK200550FP	22,91	22,30	31,16	23,63	29,03	67,86	2,85	0,25	higher
SK200560FK	10,37	25,77	28,56	35,30	11,90	65,87	21,46	0,77	lowered
SK2005700F	4,50	27,36	39,26	28,89	16,42	56,39	25,24	1,95	lowered
SK2005800P	44,65	42,50	10,66	2,19	45,32	45,85	5,31	3,52	quite high
SK200590FP	1,40	42,85	30,78	24,98	2,08	92,95	4,97	0,00	higher
SK1000100P	11,55	27,70	40,47	20,27	11,55	34,73	7,35	46,37	lowered
SK1000200P	27,30	45,06	23,38	4,26	27,30	47,85	15,41	9,44	quite high
SK1000300P	20,38	50,40	20,09	9,13	20,43	61,16	11,17	7,24	quite high
SK1000400P	35,20	37,98	13,20	13,62	36,53	46,41	11,50	5,56	quite high
SK1000500P	35,20	37,98	13,20	13,62	36,53	46,41	11,50	5,56	quite high
SK1000600P	12,56	47,68	38,69	1,06	12,57	49,00	6,91	31,52	higher
SK1000700P	0,01	2,82	83,63	13,54	0,01	85,07	0,00	14,92	quite low
SK1000800P	8,21	38,07	43,20	10,52	8,84	41,70	4,63	44,83	lowered
SK1000900P	0,74	8,73	45,03	45,50	1,35	52,06	3,00	43,59	quite low
SK1001000P	6,55	27,55	46,55	19,36	13,13	67,61	5,75	13,51	lowered
SK1001100P	18,59	46,56	32,49	2,37	18,59	48,58	10,38	22,44	higher
SK1001200P	0,33	18,54	70,19	10,94	2,68	90,56	5,81	0,95	lowered
SK1001300P	6,34	53,70	37,32	2,64	39,21	58,70	1,80	0,28	quite high
SK1001400P	2,68	51,66	31,47	14,19	4,18	93,48	2,04	0,30	higher
SK1001500P	2,35	36,80	52,01	8,84	5,26	94,19	0,00	0,55	higher
SK1001600P	21,07	63,93	11,13	3,87	21,41	68,83	5,35	4,41	quite high

ANNEX H
CHEMICAL COMPONENTS OF THE PRESENT GROUNDWATER MONITORING NETWORK

Baseline set:	**Additional set:**
Physical-chemical parameters =ZFCHR	***Physical-chemical parameters =ZFCHR***
Na	H_2S
K	Sum of CN
Ca	***Common organic matter***
Mg	Tenzides
Mn	NEL (hydrocarbon index)
Fe	***Specific organic constituents***
NH_4	***Pesticides***
NO_3	DDT
NO_2	Heptachlor
Cl	Hexachlorobenzene (HCB)
SO_4	Lindane (HCH)
PO_4	Methoxychlor
SiO_2	***PCB congeners***
CO_3	Congeners – 28, 52, 101, 138, 153, 156, 180
HCO_3	
COD-Mn	***Aromatic hydrocarbons***
Aggressive CO_2	1,2-dichlorobenzene
O_2	1,3-dichlorobenzene
% of saturation O_2	Benzene
Soluble matters by 105°C	Chlorobenzene
pH	***Chlorinated phenols***
acidity	Dichlorophenol
alkality	Pentachlorphenol
color	TCP (2,4,5-trichlorophenol)
turbidity	TCP (2,4,6-trichlorophenol)
Trace elements	***Chlorinated hydrocarbons***
As	1,1-dichloroethene
Al	1,1,2-trichloroethene (TCE)
Cr	1,1,2,2-tetrachloroethene (PCE)
Cd	1,2-dichloroethanen
Cu	Carbon tetrachloride (CCl4)
Ni	Chloroethene
Pb	Chloroform
Hg	***Polynuclear aromatic hydrocarbons***
Zn	Benzo(a)pyrene
Common organic matter	Fluorantene
TOC	

ANNEX I
PRESENT MONITORING DENSITY (GROUNDWATER QUALITY)

Quaternary bodies

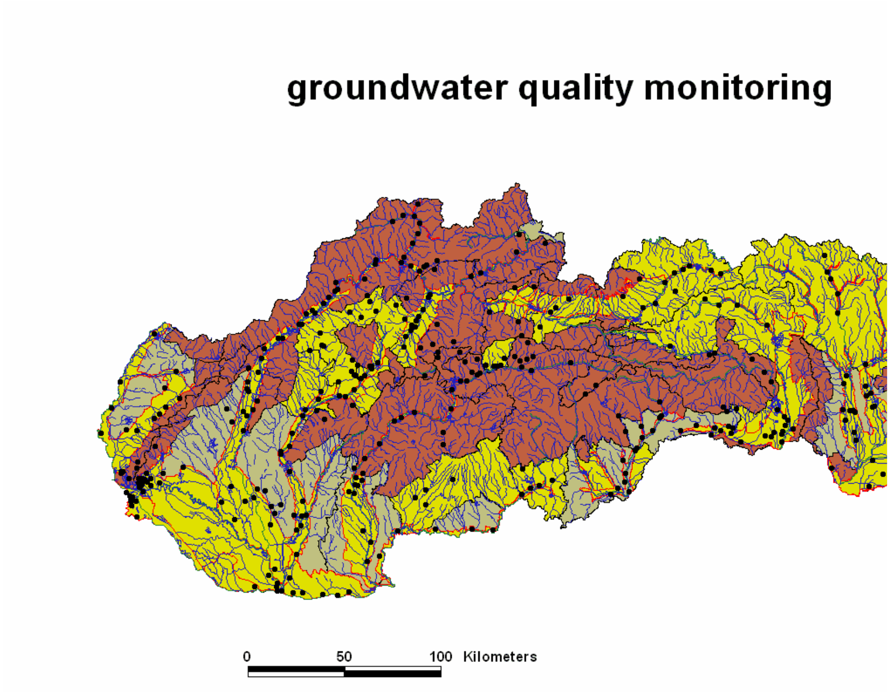
gw body	area	wells	wells/1000 km2
SK1001400P	34	4	116
SK1000800P	198	8	40
SK1000500P	1,069	42	39
SK1001100P	280	11	39
SK1000700P	724	18	25
SK1000200P	519	12	23
SK1000400P	1,943	41	21
SK1001200P	934	18	19
SK1000900P	111	2	18
SK1001000P	421	7	17
SK1000100P	830	13	16
SK1001500P	1,471	23	16
SK1000600P	515	6	12
SK1000300P	1,668	17	10
SK1001300P	36	0	0
SK1001600P	33	0	0
16		**222**	

Pre-Quaternary bodies

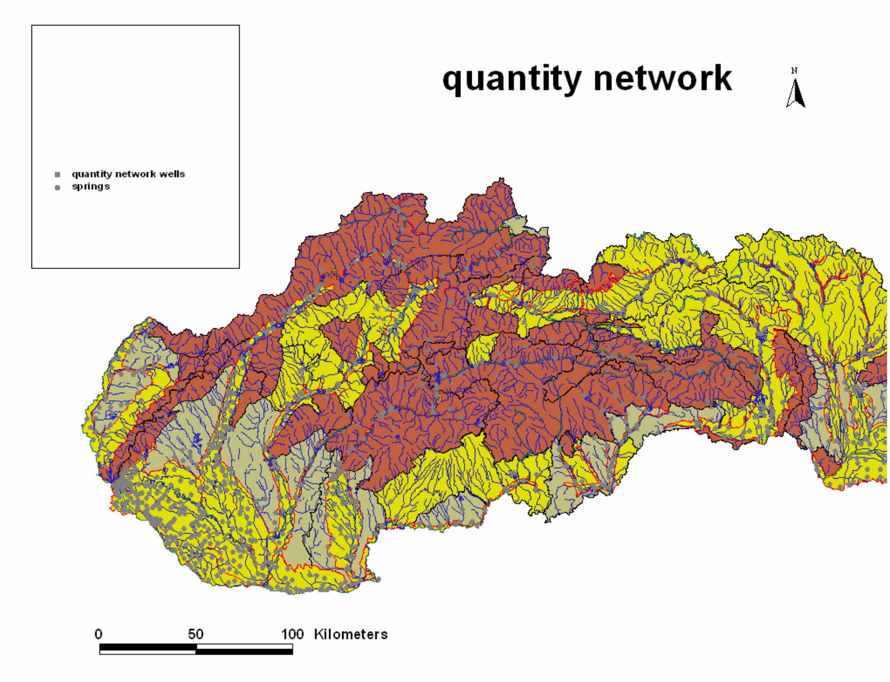
UTVARU	AREA_KM2	RISK	wells	wells/1000 km2
SK200290FK	171	1	5	29
SK200250KF	168	0	3	18
SK200010FK	179	0	3	17
SK200140KF	1,126	1	13	12
SK200300FK	295	0	3	10
SK200480KF	595	1	5	8
SK200510KF	384	0	3	8
SK200150FP	579	0	4	7
SK200390KF	331	0	2	6
SK200170FP	336	1	2	6
SK200200FP	179	0	1	6
SK200110KF	194	0	1	5
SK200270KF	1,006	0	5	5
SK200240FK	407	0	2	5
SK200280FK	3,509	0	17	5
SK200030FK	222	0	1	5
SK200340KF	229	1	1	4
SK200160FK	279	0	1	4
SK2003100P	564	1	2	4
SK200540FP	306	0	1	3
SK200080KF	312	0	1	3
SK200260FP	1,440	1	4	3
SK200460KF	390	0	1	3

UTVARU	AREA_KM2	RISK	wells	wells/1000 km2
SK2004700F	1,696	1	4	2
SK200500FK	1,041	0	2	2
SK2004900F	1,648	0	3	2
SK2001800F	4,441	0	8	2
SK2003300F	587	1	1	2
SK2001000P	6,250	1	9	1
SK2000200P	1,482	1	2	1
SK200220FP	2,677	0	3	1
SK2005300P	1,122	1	1	1
SK2005700F	4,081	1	2	0.5
34			116	

ANNEX J
PRESENT QUALITY MONITORING NETWORK


groundwater quality monitoring
0
50
100
Kilometers

ANNEX K
PRESENT QUANTITY MONITORING NETWORK


quantity network
N
quantity network wells
springs
0
50
100 Kilometers