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# Draft Updated Integrated Tisza River Basin Management Plan

## Annex 8. Groundwater bodies status assessment methodologies in Tisza countries

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# Contents

# 1 Background

## Introduction

Data presented in this report summarize relevant information for Tisza River Basin (TRB) for groundwater bodies. Tisza countries reported templates that follow approach applied for development of the First Integrated Tisza River Basin Management Plan (1st ITRBMP) and other studies and background documents relevant for Tisza River Basin within the scope of International Commission for the Protection of the Danube River (ICPDR) Tisza Group and other ICPDR expert groups. Within this Annex Tisza river countries reported national methodologies for groundwater status assessment.
Annex X Groundwater Status Assessment Methodology presents one of the base documents for developing part of Second Integrated Tisza River Basin Management Plan (2nd ITRBMP) concerning groundwater issues.
In order to successfully develop 2nd ITRBMP some basic documents had to be taken into account. As roof document WFD has been considered, as well as daughter Directive – Groundwater Directive. As main starting point the 1st ITRBMP plan was used. Brief description of mentioned documents will be given in following chapters.

## Water Framework Directive

Water Framework Directive (Directive 2000/60/EC), as roof document, has purpose to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater, and prevent their further deterioration.
Monitoring of surface water status, groundwater status and protected areas is defined within Article 8 of WFD. In Article 8 is defined, inter alia, that:
Member states shall ensure the establishment of programmes for the monitoring of water status in order to establish a coherent and comprehensive overview of water status within each river basin district:

- For groundwater such programmes shall cover monitoring of chemical and quantitative status

Based on the monitoring results, groundwater status will be defined. Total groundwater status is defined thru quantitative and chemical status. Groundwater body has a good status only if a quantitative and chemical status are rated as *good*. In case that chemical and/or quantitative status are rated as poor, total status of GWB is poor. Annex V of WFD detailed description of groundwater monitoring, as a starting point for status assessment, is provided. Groundwater monitoring is divided to monitoring of quantitative status and monitoring of chemical status. Chemical monitoring is further divided to surveillance and operational monitoring. Within this annex detailed instruction for performing of mentioned types of groundwater monitoring has been given. Based on monitoring results, quantitative and chemical status is defined and therefore overall status of GWB can be determined.

## Groundwater Directive

In order to further institutionalize and organize protection of groundwater, Groundwater Directive has been adopted in 2006 (Directive 2006/118/EC). This Directive defines detailed procedures for assessing groundwater chemical status, identification of significant and sustained upward trends and definition of starting points for trend reversal and measures to prevent or limit inputs of pollutants into groundwater. All mentioned activities cannot be performed without results of groundwater monitoring, so that monitoring represents the basic „tool“ for all further activities on protection of groundwater.

## Introduction – 1st TRBM, and other background studies

The 1st Integrated Tisza River Basin (TRB) Management Plan was adopted in 2011. Plan was based on data provided by Tisza countries (Ukraine, Slovakia, Romania, Hungary and Serbia for the reference year 2007 (The first Tisza Analyses Report was developed).
In comparison with the DRBM Plan, the ITRBM Plan took into account rivers with catchment size larger than 1000 km$^2$ instead 4000 km$^2$, natural lakes >10 km$^2$ instead 100 km$^2$, main canals and groundwater bodies >1000 km$^2$ and of basin-wide importance.
This means that in compared to the 11 identified transboundary groundwater bodies or groups of groundwater bodies of the Danube Basin-wide importance (so called "Roof level", presented in the DRBMPs), the Tisza countries have collected and evaluated information related to:

- 85 national and transboundary groundwater bodies of importance to the Tisza River Basin, according to agreed criteria for importance (all GW bodies >1,000 km$^2$ and those TB GW bodies <1,000 km$^2$ considered to be of basin-wide importance);
- The assessment of pressures on the quantity of the groundwater bodies of basin-wide importance showed:
  - That over-abstraction prevents the achievement of good quantitative status for twelve groundwater bodies;
  - For ten groundwater bodies, the most significant pressure on quantity is illegal abstractions and indirect abstractions, by drainage or gravel pits (in Hungary);
  - Other significant pressures include abstraction for agriculture, public water supply and industry.

# 2- Groundwater status assessment methodologies applied by Tisza countries

Ukraine, Slovakia, Romania, Hungary and Serbia are countries within Tisza river basin. Hungary, Romania and Slovakia as EU members had obligation to develop and implement groundwater status assessment methodology. On the other hand, Ukraine and Serbia are not EU members and still did not develop groundwater status assessment methodology.

## Ukraine

### Chemical Risk Assessment

In Ukraine, risk assessment of failing good chemical status in 2021 was performed based on following criteria:

- Previous risk and chemical status assessments;

One GWB UA_TIS_GW_4 7 was identified "at risk" of failing good chemical status in 2021.

### Quantitative Risk Assessment

All groundwater bodies according to risk assessment of failing good quantitative status in 2021 were classified "at no risk".

# Romania

## Chemical Status Assessment

The methodology for the *chemical status* assessment followed the requirements of the Groundwater Directive (2006/118/EC) as well as the recommendations of the CIS Guidance Document no. 18 – Guidance on Groundwater status and trend assessment. The first step was to check any exceedances of TVs which were established taken into consideration the NBL values. If no exceedances of the TVs have been recorded, the groundwater body has been considered as being in good chemical status. If exceedances of TVs were recorded the following relevant tests were carried out:

- **General assessment of the *chemical status*:** Data aggregation was performed and it was checked whether the total area of exceedance was greater than 20% of the total area of the GWB. The test showed a *good status* for the water body if no exceeding occurs.
- **Saline or other intrusion:** not relevant.
- **Significant diminution of associated surface water chemistry and ecology due to transfer of pollutants from the GWB:** The location of the exceedance of the relevant TVs was not found in areas where pollutants might be transferred to surface waters. A comparison of the pollutant load transferred from the GWB to the surface water body with the total load in the surface water body did not exceed 50%. The test showed a *good status* for the water body.
- **Significant damage to GWDTEs due to transfer of pollutants from the GWB:** No GWDTE was found to be damaged. The test showed a *good status* for the water body;
- **Meets the requirements of WFD Article 7(3) –** Drinking Water Protected Areas: there is no evidence of increased treatment due to changes in water quality. The test showed a *good status* for the water body.

The methodology for TV establishment in Romania has been developed according to CIS Guidance No. 18. NBL are the key elements in the process of TV setting. As described above, during the TV establishment, the NBL have been compared with the drinking water standards.
The maximum allowable concentrations (MAC) provided by the Law no.458/2002 as amended, were chosen as TV where NBL are smaller than MAC. Where NBL are higher than MAC, a small addition of 0.2 NBL was used, in order to avoid misclassification of the respective GWB (TV = NBL + 0.2 NBL = 1.2 NBL).
The updated list of TVs established for each GWB was published in the new Order of the Minster no. 621/2014 approving TV for GWBs from Romania.

To assess the chemical status of the groundwater bodies, the following steps are considered:

- The annual average concentrations for each monitoring point and for each indicator were calculated;
- For each monitoring point the annual average concentration of each parameters was compared to the threshold values (determined for each GWB) or standards value (nitrates and pesticides).
- The GWB is in good chemical status when EQS or TVs are not exceeded at any monitoring point.
- The GWB is in poor chemical status when EQS or TV are exceeded at monitoring points representing more than 20% of the GWB surface.

The trend assessment was also performed based on 2000-2013 time series.
The methodology for identifying significant upper trends consists in adjustment and aggregation of the data from each monitoring points on groundwater bodies. The trend analysis was done using the GWSTAT program. The steps used for trend assessment were:

- Identifying the monitoring points and the number of analysis and assessment of data series, for each year of reference period (2000–2013)
- Identifying of the baseline concentration for each parameter as the average concentration registered during the year 2000
- Calculation of annual average for the available data in each monitoring point
- Significant upward trends have been identified by GWSTAT software, based on ANOVA Test.

Trend reversal assessment methodology consists also in the use of GWSTAT software, which, based on the 2 sections model, and processing the introduced data series, can indicate an inversion in the trend slope, thus a trend reversal.

### Quantitative Status Assessment

The quantitative status of the groundwater bodies has been assessed taking into account the CIS Guidance no.18.
The following criteria have been used:

- water balance
- the connection with surface waters
- the influence on the terrestrial ecosystems which depend directly on the GWB
- the effects of saline or other intrusions

The quantitative status analysis has been done for each phreatic groundwater body by comparing the average of the hydrostatic level from 2013 with the multiannual average levels during the whole observation period.

## Slovakia

### Chemical Risk Assessment

In Slovakia, risk assessment of failing good chemical status in 2021 was performed based on following criteria:

- Previous risk and chemical status assessments;
- Environmental load;
- Vulnerability;
- Active substances in pesticides and fertilizers,
- Drainage protection;
- Safeguard zones and protected areas;
- Climate, population and land use changes;
- Interaction with surface water.

The chemical status assessment for the 2nd planning cycle was based on the chemical status evaluation for the 1st planning cycle, elaborated in the Slovak Waters Plan (MoE SR, 2009). The chemical status was assessed in accordance with Annex III. Of Directive 2006/118 / EC (on the protection of the Pollution and deterioration of quality) and was based on an overall assessment of the quaternary chemical status and pre-quaternary bodies of groundwater classified in 2009 in the Slovak Waters Plan1in bad chemical status (MoE, 2017).
SK8 have a good chemical status, but according to risk assessment of failing good chemical status in 2021 groundwater body SK1000200P was classified “at risk” because of several reasons. The groundwater body is highly vulnerable. There is expected continued frequent use of plant protection products on the farms and relatively high number of point sources of pollution is located in the groundwater body. Up to 6 indicators of the previous chemical assessment exceeded the limit in Unit SK1001200P (10.0b). The reason is especially high vulnerability (10.0b) and insufficient drainage (7.0b). Other factors do not reach high values, the department is however, at risk (5,6b) (HORVÁT O., PATSCHOVÁ A.).
To assess chemical status, the proposed methodology stems from the feasibility of the input information, conceptual model and the hydrogeochemical and hydrogeological interpretation of conditions in the Slovak Republic. Article 3.2 of the Groundwater Directive offers the possibility to establish TVs at: the national level; the river basin district level; the level of the area of the international river basin district falling within the territory of a Member State; or at the level of a GWB or group of GWBs. In the Slovak Republic, the NBL and TVs were established at the level of the GWB.

Determination of natural background levels:
The input data consists of the database from the Geochemical Atlas of the Slovak Republic (spatial factor, 16 359 samples) and the results of national monitoring of groundwater quality (time factor, 16 475 samples) in Slovakia. The next step was to eliminate each sample with anthropogenic impacts (pre-selection method with

half the DWS for each compound). Sample elimination was also done in cases where just one compound failed to satisfy this principle. For determination of the NBL, a statistical method was used (NBL=median+2*median absolute deviation). For the treatment of less than LOQ (limit of quantification), measurements were applied according to the following system: simple substitution (LOQ*0.5, when <40% values are below LOQ), 40-60% - Kaplan-Meier´s analysis was used and over 60% NBL=LOQ). NBL were estimated for: NO3, As, Cd, Pb, Hg, NH4, Cl, SO4, Na, K, Ca, Mg, Sr, PO4, HCO3, Fe, Mn, Cr, Cu, Se and Al. For synthetic organic compounds (not originating in a natural way) the NBL was “zero concentration” and this is practically the value of the LOQ of a single organic compound.
Threshold values:
The TV is a half the interval between the determined NBL and the reference (drinking water standard). As the TV can be below the gelogenic concentration in groundwater, for example in the case of heavy metals, the TV will be assessed on the basis of the natural background level (TV = NBL).

Chemical status:
For chemical status assessment, general assessment of the chemical status of the GWB as a whole was applied. Input data results from the quality monitoring network from 2010 (surveillance monitoring) and 2011 (operational monitoring) were used. Criteria for assessing the groundwater chemical status for this test were drinking water standards and TVs. The annual arithmetic mean concentration of the relevant pollutant at each monitoring point was the basis for aggregation on the level of a GWB. In the case of non- exceedances, the GWB is recommended to be of good chemical status for the relevant parameters. Also trend analysis were performed in each monitoring site in order to identify significant and sustained upward trend in concentration of pollutants.
The next step was to calculate the extent of exceedance of mean values by using the Kriging method - in the case of quaternary GWB (porous permeability and over five monitoring points). An acceptable extent of exceedance would not exceed 20% of the total GWB. In the case of pre-quaternary GWBs with fissure, karst, karst-fissure permeability, annual average concentrations with 20% confidence intervals were used. The final assessment of the chemical status of the GWB and its verification was performed using a GIS technique via comparison with maps of land use, point sources of pollution, hydrogeological and hydrogeochemical conditions in the GWB.

## Quantitative Risk Assessment

GWBs quantitative status is based on the essential requirement of Directive 2000/60 / EC, which sets out as the basic indicator quantitative status steady state of groundwater level, respectively, extends the springs (table 2.1.2 of Annex V directive) and spreads them assessment process with further test criteria. The following criteria were used for this evaluation: (a) an assessment of the quantities of groundwater based on the water balance approach (using the published data from 141 hydrogeological units), (b) assessment of changes to the groundwater regime (use of the results of the groundwater monitoring program from the state monitoring network of SHMI),c) evaluation of the river flow rate in the relation of groundwater abstraction located above the surface water balance profile, (d) assessing the impact of groundwater abstraction on dependent terrestrial ecosystems from underground water. Quantitative status evaluation was elaborated in accordance with the approved National quantitative status evaluation methodology of the bodies of groundwater in Slovakia prepared in 2008.
This methodology and the results of GWB quantitative status and risk assessment were published in I. and II. Water plan of Slovakia (2009, 2015). In the II. Water plan groundwater data from period 2004 to 2012 were used for the assessment process and according to the risk assessment of failing good groundwater quantitative status in 2021 we do not have any transboundary groundwater body at risk.
Quantitative status for GWBs was determined by applying 3 tests:
1. Water balance test:
National methodology determined that long-term annual abstraction from the GWB must not exceed 80% of available groundwater resources defined in WFD. Quantification of available groundwater resources was

based on national quantification and categorization of available groundwater amounts in hydrogeological units transposed to Quaternary and Prequaternary groundwater bodies (8 categories with different accuracies for determined available groundwater amounts were used). The accuracy of determined available groundwater amounts on the national level varying from 100% (water balance evaluation, long term stable abstraction) to 30% (less than one year monitoring, short term pumping test etc.). Available groundwater resources for GWB (according with WFD) is the sum of available groundwater amount in the individual categories multiplied by the coefficient of accuracy - from 1 to 0.3).

2. Groundwater level and discharge test:
Identifying the presence of sustained long-term declines of groundwater level in wells or groundwater discharge in springs caused by long-term groundwater abstraction was based on the statistical evaluation of long-term groundwater monitoring data from the national groundwater monitoring network. Non-parametric Mann – Kendell test (95% and 99% probability) and parametric test SLOPE (gradient of linear regression test) were used for the evaluation of the significance decreasing of groundwater regime.

3. Surface water flow test:
Evaluation of surface water discharge in surface water balance profiles linked to the groundwater abstraction (inside of surface water bodies). The sum of the long-term average groundwater abstraction in the balance area above the surface water balance profile (failing determined environmental flow limits) must not exceed 50% from Q180 (2011) or 100% from Q355 (whole monitoring period).

4. Terrestrial ecosystems dependent on groundwater test:
Evaluation of terrestrial ecosystems was not applied.

# Hungary

## Chemical Status Assessment

Assessment of the chemical status of GWBs was conducted as follows: Analysis of the chemical data of individual monitoring points within each of the GWBs; Identification of the pressures - sources of pollution; The Natural Background Levels (NBL) were calculated and used to determine threshold values (TV). TVs have been determined according to CIS Guidance No. 18. Contamination limits have been determined for all indicators listed in Annex II Part B of Directive 2006/118/EC and indicators of the report under Art. 5 of Directive 2006/118/EC.
The following parameters were investigated:

a) NBL was determined for the following components: nitrate, ammonium, specific conductivity, sulphate, chloride, arsenic, cadmium, lead, mercury,

b) For each monitoring point the median concentration of each parameters of the studied period was compared to the TVs (determined for each GWB) or standards values (in the case of nitrates, metals and pesticides).

c) Different tests were conducted to assess GWB status: Diffuse pollution test (nitrate, ammonium), Drinking water supply tests for numerous elements or components in both drinking water wells and monitoring wells and trend analysis based on the data of the surveillance monitoring system. Studied components of these tests are: nitrate, ammonium, chloride, sulphate, specific conductivity, mercury, lead, cadmium, pesticides and organics, furthermore in the trend analysis pH and dissolved oxygen.

d) Based on these tests, GWB was evaluated.

## Quantitative Status Assessment

To determine the overall quantitative status for a GWB, a series of tests were applied that consider the impacts of anthropogenically induced long-term alterations in groundwater level and/or flow. Each test was assessed whether the GWB meets the relevant environmental objectives. The quantitative status has been assessed taking into account CIS Guidance No.18. The following criteria have been used:

- GW alteration (Drawdown) test
- Water Balance test
- Surface Water Flow test
- Groundwater Dependent Terrestrial Ecosystems (GWDTE)
- Saline or other Intrusion test

For GWBs no **Risk assessment** was performed in the 2nd RBMP HU.

# Serbia

## Chemical Risk Assessment

Since Serbia is not an EU member, still didn't create and adopt methodology for groundwater status assessment. Instead of that in following text, methodology for chemical risk assessment will be given.

In order to successfully perceive potential risks for groundwater quality, it is necessary to overview natural and anthropogenic factors which may affect groundwater quality in some area.
As stated previously, potential risk for groundwater quality includes natural as well as anthropogenic factors. In order to perceive those factors potential groundwater risk map should be produced. Producing of this map meant „overlapping" of maps with natural terrain characteristics with maps with anthropogenic influence.
Anthropogenic influences on groundwater quality were examined using following maps:

- Map 1 - number of inhabitants without sewerage systems,
- Map 2 - number of inhabitants with septic tanks,
- Map 3 – number of cattle by hectare of arable land,
- Map 4 – land use – CORINE Land cover

For all mentioned maps, content was sorted into 5 categories with different weight factors for each category in order to be compatible for „overlapping".
Natural characteristic, which may affect groundwater quality in Republic of Serbia have been analyzed based on groundwater vulnerability map. Vulnerability map has been created using several base maps in order to produce as much as possible accurate map of groundwater vulnerability in Republic of Serbia.
For producing vulnerability map following base maps have been used:

- Map I – influence of terrain inclination on infiltration,
- Map Z – influence of soil type and vegetation (pedology map),
- Map D – overlying strata thickness,
- Map A – aquifer geological and hydrogeological characteristics and
- Map N – groundwater level – depth to groundwater level

By compiling of presented parameters, with different weight factors, vulnerability map is produced. Based on obtained results, vulnerability index in categorized into 7 categories.
For the needs of further analyses starting 7 categories has been reduced to 6 by grouping.
By analyzing of mentioned parameters and maps thru iterative process of calibration and by comparison with actual data for certain locations final vulnerability index formula was obtained. This map combines natural and anthropogenic factors.

By presented methodology groundwater vulnerability index range has been obtained. By further analysis limit for vulnerability index was established. Further groundwater bodies map was overlapped with produced map. In this manner zones where vulnerability index is below defined limit, groundwater bodies are not at risk, and vice versa.

## Quantity Risk Assessment

Since Serbia is not an EU member, still didn't create and adopt methodology for groundwater status assessment.

The assessment of the quantitative risk was based on the existing monitoring data on the groundwater exploitation and its influence on groundwater level. Data on exploitation of groundwater have been collected through a group of strategic projects in the period 2006-2011, as well as through an overview of the existing documentation - elaborate on reserves and other available technical documentation and studies.

In the past decades, monitoring of the groundwater level has been carried out. These data are significant from the perspective of the trends in the groundwater level regime. For deeper aquifers in Tisza basin (basic water bearing complex), it can be concluded that there is no adequate observation network that can with sufficient certainty determine the effects of exploitation groundwater level.

Since lack of adequate data sets and monitoring network, especially for deeper aquifers, overall risk assessment for groundwater in Tisza river basin was carried out based on expert judgement.

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