Slovenian Rules on criteria for the designation of a water protection zone

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1 Introduction

Slovenian legislation dealing with water protection zones is presented the following regulation that was the source for preparing this report:

Rules on criteria for the designation of a water protection zone (Official gazette of republic of Slovenia No. 64/04, 5/06 in 58/11), *original title: Pravilnik o kriterijih za določitev vodovarstvenega območja*.

In the following chapters a summary of this regulation is presented.

2 Content of the Rules

Relating to water bodies or parts thereof (hereinafter referred to as the body of water) that is used or intended for the abstraction of water these Rules provide:

- criteria for determining the external and internal boundaries of water protection areas,

- criteria for determining water protection regime in relation to interventions in the environment, which can pose risk of pollution of the water body, and

- other issues necessary to determine the water protection area.

The provisions of these Rules shall apply for the protection of water bodies, which are used or intended for the abstraction of water for:

- public drinking water supply,

- human consumption, in the case of mineral and thermo-mineral water, and

- manufacture of beverages.

3 Starting point for delineation of protection areas

Starting point for delineation of protection areas is based on:

1. natural features of the water body and its recharge zones that protect water bodies from pollution or other types of pollution,
2. long-term significance of the water body for local and regional development,
3. conditions of the provision of drinking water and the requirements of regulations governing drinking water,
4. estimates of actual and potential pathways of microorganisms along the flow of water to capture,

5. estimates of actual and potential pathways of chemical and physical pollutants downstream of surface water and groundwater to capture,
6. risk of pollution due to environmental interventions (Annex 1), and
7. costs for the establishment of water protection regime and the costs for setting up the technology of preparation and purification of water taken from the body of water that is protected by water protection regime.

In determining the risk of pollution it is necessary to consider the type of intervention in the environment and the associated adequacy of the envisaged technologies, microbiological, chemical and physical properties of pollutants that could endanger the body of water, and natural features of the recharge area of capture.

Water protection area must be defined so that it is possible to implement water protection regime to the extent and in a manner which ensures the preservation of the natural state of the water body.

Irrespective of this, in case if water protection area in an area that is already at risk, water protection areas should be defined in a such way that it is possible to implement water protection regime at least to the extent and in a manner which ensures reduction in the risk of pollution due to human intervention in the environment from Annex 1 to a level that is acceptable for the abstraction of water.

3.1 Capture area (abstraction zone)

- The capture area is the enclosed (fenced) area of water adjacent to the capture.
- The capture area should provide protection of the water capture against direct damage of capture facilities and direct entry of pollutants into the capture, or its proximity.
- In the capture area only the maintenance and renovation of facilities that serve the capture are allowed.

3.2.1 Determination of the border of capture area

(1) The boundary of the capture area is generally around 10 m and/or upstream of the well or drainage.
(2) The boundary of the capture is generally 20 m around the capture of karst spring.
(3) The boundary of the capture is generally at least 20 m around the capture on surface water body, with fenced borders on land and floats for border on water.
(4) The boundary of the capture is generally at least 20 m around the capture, if it is in the riverbed of surface water, while the border with floats need not be marked if the hydraulic conditions do not allow this, but at the capture boards have to be placed, which prohibit approach and have to be legible from a distance 50 m.
(5) If the capture is on the river bank of the flowing surface water and the width of the channel at low water conditions is less than 20 m, the area of the capture has to include the 10 m belt on the opposite bank of the capture.
(6) The capture area also includes drainage legs, drainage channels, galleries and fissures that have a direct connection with the capture.

3.2 Protection areas

Water protection area can be divided due to the different levels of protection, namely:

1. outer area with the moderate protection regime (III),

2. middle area with the rigorous (strict) protection of the water protection regime (II),

3. inner area with the most rigorous protection regime (I).

- Outer water protection area covers the whole catchment area of the capture (spring/well) and is intended for the provision of long-term drinking water health. In this area the water regime is in order to ensure an acceptable risk for pollution of the water body with radioactive materials or substances, which are persistent, or decompose very slowly.

- Middle water protection area is the area which, according to natural conditions, provides a sufficiently long residence time, sufficient dilution and sufficient time for water filtration action. In this area the water regime is to ensure an acceptable risk for pollutant of the water body with pollutants, which slowly diminish.

- Inner water protection area is the closest to the capture, where, according to the natural conditions, dilution of pollutants is small and pollutants quickly arrive to the capture. In this area the water regime has to ensure an acceptable risk for pollution of water body with micro-organisms and other pollutants.

If the analysis of the risk of pollution already implemented environmental interventions in the water protection zone follows that water protection regime in relation to new interventions in the environment provides an acceptable risk of pollution of the water body only in one part of inner area, the area must be split into two or more smaller sub-areas, which apply water protection regimes of different complexity.

3.2.2 Water protection regimes

The water protection regime is provided in the form of prohibitions, restrictions and protection measures for interventions in the environment, which are listed in Annex 1. In inner water protection areas all interventions marked with »-« are prohibited. Interventions marked with »pp« and »pip« are also prohibited, if the risk analysis was not performed, or the risk analysis results have shown that risk for water pollution is not acceptable.

In case of »pip« the intervention has to be included in the state or municipal spatial plan. The Spatial plan has to be verified by environmental report and the assessment of the effects on the environment. Impacts of the intervention on water regime and status and the design of protection measures has to be verified by risk analysis in the Spatial plan enacting procedure.

In case of »pp« design of protection measures of the intervention has to be verified by risk analysis. Impacts on water regime and status have to be verified in the construction permitting procedure.

Mark »pd« means that impacts of the intervention on water regime and status have to be verified in the building permitting procedure.

In water protection areas all interventions marked with »+« are allowed.

3.2.3 Criteria for determination of the size of protection areas

(1) The size of the protection areas is determined according to the type of surface- or ground-water body and characteristics and their recharge area and on the basis of residence (retention) time of pollutants, dilution of pollutants from the site of input to the capture or the time for action.

(2) Residence time and dilution of pollutant from the input point to the capture depends on the water velocity through the aquifer, which is determined on the basis of water inflow time estimates from any point in the recharge area to the point of capture.

(3) Time of the water inflow shall be calculated on the basis of measurements and model calculations. Time is the sum of the inflow of pollutants to the capture from the input point to the groundwater flow (travel time through the unsaturated zone) and the flow of pollutants within the groundwater (travel time in the saturated zone).

(4) The time for action is determined on the basis of estimates of time of implementation of possible intervention measures and the measures dealing with the effects of pollution before the pollutants arrive to the capture.

3.2.4 Determination of the size of protection areas

The size of the water protection area shall not be less than the natural recharge zone, which is calculated as follows:

$P\ [m^2] = Q_0 / Q_{recharge}$,

where:

- $Q_{recharge}$ [m/s] is the amount of recharge of the water body by precipitation, from surface water and from groundwater inflows. All forms of recharge of the water body are expressed as equivalent quantity of precipitation (m^3) in a unit area (m^2) per unit time (s).

- Q_0 is the average flow of water abstraction [m^3/s].

Surface water protection area of groundwater capture in springs is calculated that the average flow of water abstraction takes into account the average daily discharge.

In calculations of the amount of recharge of water body that is used for the water abstraction also following quantities should be considered: the amount of water inflow from the river bed, from tributaries, from the inflows from other aquifers, and the quantities of not captured outflows out of water protection area.

The protection zones should also cover areas outside the boundaries of the recharge area, in case the risk of pollution of the water body or the likelihood of changes in

quantitative status or direction of water flow outside the borders of the recharge zone is not negligible.

4. KARST AQUIFERS

4.1 Water protection areas determination for karst aquifers

For determination of water protection areas for the protection of the water body within the karst aquifer, it should be noted that:

(i) The groundwater flow has characteristics of turbulent flow through the channel and cannot be described by calculations based on the Darcy equation and it is therefore not possible to draw groundwater contours and determine isochrones (lines with the same travel time);

(ii) The groundwater generally flows with velocities that are significantly greater than 10 m per day, and are strongly dependent on hydro-meteorological conditions;

(iii) The distribution of groundwater velocities is very heterogeneous and therefore the risk of pollution does not decrease with distance from the capture;

(iv) The retention and filtering capacity of the aquifer may be poor, in the open karstified areas these capacities are negligible;

(v) The microorganisms traveling through the porous media under most conditions cannot be degraded.

The water protection area of karst aquifers is determined according to the intervention time and, if possible, also with regard to the retention time of pollutants and dilution of the pollutants.
In addition to the above mentioned criteria it should be noted that for the water capture in the karst aquifer:

(i) Within the Outer water protection area capture has to be protected with a sufficiently long retention time of pollutant in the covering layers or the unsaturated zone of the aquifer, or with sufficient dilution of pollutant, so that the implementation of intervention measures and elimination of pollution in the capture is possible.

(ii) Within the Middle water protection area the capture has to be protected with the implementation of intervention measures in a very short time, since the pollution in this area has rapid and strong impact on the capture due to the possible penetration of pollutants through the karstified areas to groundwater or to the groundwater in karst channels, the implementation time for exacting intervention measures is very short.

(iii) Within the Inner water protection area protection of the capture has to be ensured from any pollution, because the pollution in this area has fatal consequences for capture due to

potential infiltration of pollutants through karstified areas into the groundwater system, or the groundwater flows in karst channels, therefore, the implementation of intervention measures in this area is impossible.

4.2 Border of water protection area for karst aquifer

The border of **the water protection zone for a karst aquifer** (Figure 1) is equal to:

1. for the Outer area (III): the external border of catchment area,

2. the Middle area (II): the border of karstified area from where the travel time to the capture is more than 12 hours, and

3. the Inner area (I): the border of karstified area from where the travel time to the capture is less than 12 hours.

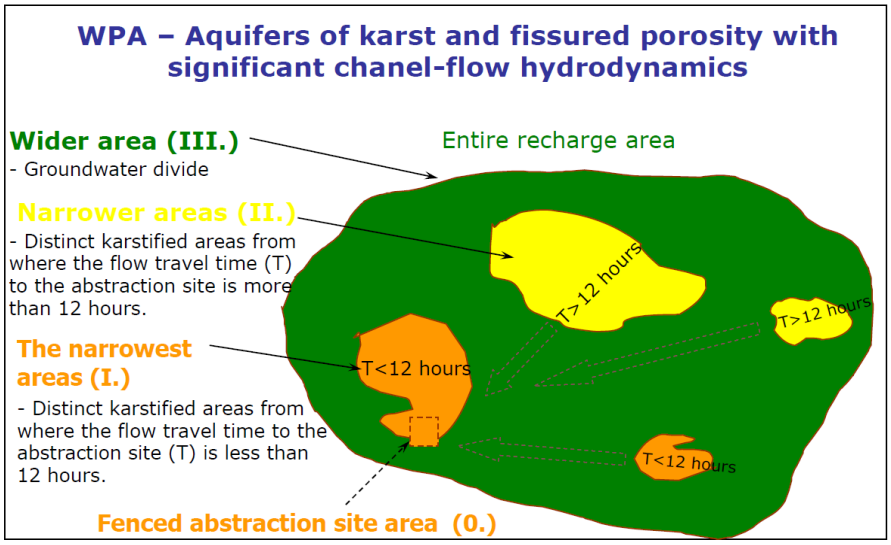

Figure 1: Water protection zones for karst aquifers.

The border of the **Outer protection area (III) of karst aquifer** is equal to the outer border of the total natural recharge area (catchment zone).

The border of the **Middle protection area (II) of karst aquifer** is determined by:
(i) fractured areas with high flow velocities, together with the main and tributary flows to the capture,
(ii) swallow hole areas including areas of potential surface runoff in the swallow hole area with a direct link to the groundwater level,
(iii) areas of karst poljes (including areas of potential surface runoff into the swallow hole area with a direct link to the groundwater level.

Notwithstanding the provisions of the preceding paragraph, it is necessary to add karstified areas where they are covered with very low permeable and continuous geological layers with thickness of at least 8 m, or if the covering layers contain a perched/aquifer, or where groundwater is separated from the aquifer by a very low permeable layer with a thickness of at least 5 m.

The border of **Inner protection area (I) of a karst aquifer** is determined by:
(i) karstified and fractured areas with a direct link to the capture or pumping station,
(ii) fractured areas with high flow velocities, together with the main and tributary flows to the capture or pumping station,
(iii) swallow hole areas including areas of potential surface runoff into the swallow hole area with a direct link to the groundwater level,
(iv) areas of all karst poljes including areas of potential surface runoff on the poljes with swallow holes, which have direct link to the groundwater level.

4.3. The basis for determining the borders of water protection areas for karst aquifer

(1) The boundaries of protection areas for the karst aquifer are determined on the basis of:

- groundwater flow velocities,
- the direction of groundwater flow,
- groundwater levels,
- dilution of actual and potential pollutants,
- the size of the catchment area,
- karstification rate of the recharge/catchment area, and
- geochemical properties of groundwater.

(2) The information referred to in the preceding paragraph shall be obtained by using the following methods:

- determination of the surface recharge/catchment area according to surface morphology and the river network,
- estimation of geo-hydraulic properties of the water flow through the geological layers,
- determination of hydrogeological boundaries on the basis of stratigraphical, lithological and structural (tectonic) elements acquired by the field mapping and photogrammetric geological surveys,
- catchment area assessment to identify the origin of groundwater on the basis of assessment of hydro-geochemical units/ determination of catchment area after identifying the origin of groundwater on the basis of assessment of hydro-geochemical units,
- determination of karstified areas with speleology research, or
- tracer experiments by determining the groundwater flow velocities, dilution and dispersion parameters of pollutants.

(3) If the application of the results of only one of the methods described in the preceding paragraph does not provide reliable and efficient determination of borders, a combination of methodologies should be used to determine the border of water protection area.

5. POROUS (INTERGRANULAR) AQUIFERS

5.1 Water protection areas determination for porous aquifers

For determination of areas for the protection of the water body within the porous aquifer, the groundwater flow characteristics should be described by calculations based on the Darcy equation ($Q = k \times i \times A$), from which a piezometric map and isochrones (lines with the same travel time) should be determined, considering:

(i) The groundwater flow velocities in the porous aquifer are generally lower than 10 m per day and do not significantly depend on the hydrometeorological conditions; distribution of velocities is generally homogenous;

(ii) The risk of groundwater pollution usually decreases with the distance from the capture, the microorganisms traveling through the porous media are mostly removed.

The inner zone of porous aquifers is determined according to the retention time of pollutants and their dilution.

5.2 Border of water protection area for porous aquifer

The border of the **protection area for a porous aquifer** (Figure 2) is equal to:

(ii) for the Outer area (III): the border of catchment area,

(ii) for the Middle area (II): the minimum of the 400-day isochrone, calculated for the travel time to the capture through saturated zone, and

(iii) for the Inner area (I): the minimum of the 50-day isochrone, calculated for the travel time to the capture through saturated zone or circular line in the distance at least 50 m from the capture, if it is longer.

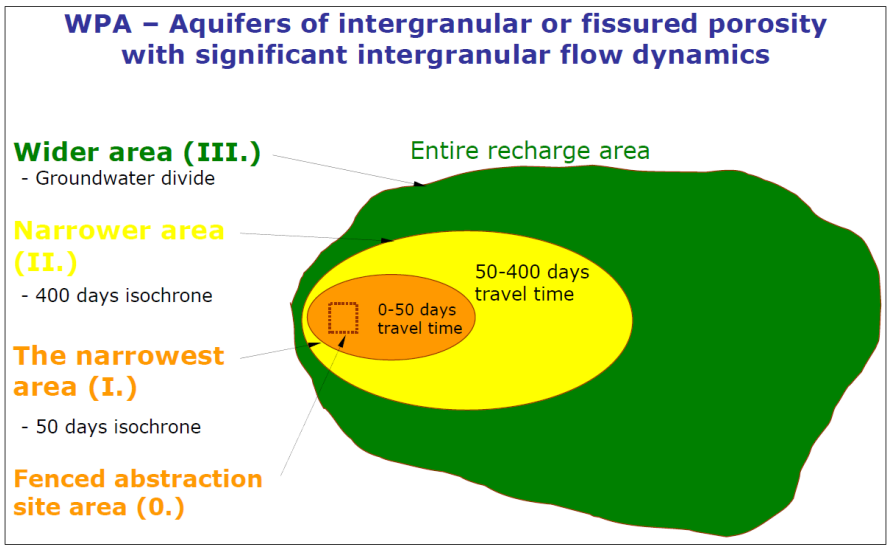

Figure 2: Water protection zones for porous aquifers.

5.2.1 External border of the water protection area for porous aquifer

(i) Irrespective of the provision 5.2, the border of the Outer area must be on the border of the depression funnel and on the external lateral current line downstream to the border of the catchment area.

(ii) In definition of the border of the Outer area from previous paragraph has to take into account also dispersion.

5.2.2 Border of the Middle area (II) for porous aquifer

(i) The surface of the Middle area cannot be smaller than the part of the capture catchment area, which provides long-term recovery of the quarter of the abstracted water volume during the average hydrological year.

(ii) The border of the Middle area can be closer to the capture in the case of an aquifer covered with continuous layers of very low permeability with thickness of at least 5 m or at least 8 m if the flow velocity is higher than 10 m/day. In this case, the border of the Middle area should be at least in a distance of 1000 m from the capture or at the 50-day isochrone.

(iii) The border of the Middle area can be closer than 50-day isochrone to the capture, if the results of the groundwater pollution risk analysis taking in the account protective measures (in accordance with the criteria for the size of protection areas mentioned in the beginning of this report) ensure that the interventions in the water protected area do not represent a risk to the water body.

5.2.3 Border of the Inner area (I) for porous aquifer

(i) The border of the Inner area is equal to the 50-day isochrone calculated for the water flow to the capture below the groundwater level through the saturated zone.

(ii) Notwithstanding the provisions above, the border of the Inner area should not be closer than a circular line around the capture with the radius of 50 m.

5.2.4 Exceptions in determining the border of the protection area for porous aquifer

(1) Notwithstanding the provisions above, the protection area is not determined if:

(i) the groundwater is taken exclusively from deep aquifers which are not supplied directly from the surface,

(ii) aquifers are covered with layers with very low permeability,

(iii) the wells for water abstraction from deep aquifers have properly sealed part above the captured layer, and

(iv) all water is protected with layers of very low permeability and appropriate thickness between the well and border, which is equal to 50-day isochrone.

(2) Enforcement of the provisions of the preceding paragraph should be justified and evidenced in the geological analysis made in accordance with the provisions of the "Planning of protection measures" (this regulation).

5.3 The basis for determination of the boundaries of protection areas

(1) The boundaries of protection areas for the porous aquifer are determined on the basis of:

- groundwater flow velocities,
- the direction of groundwater flow,
- groundwater levels,
- dilution of actual and potential pollutants,
- the size of the catchment area, and
- geochemical properties of groundwater.

(2) The information referred to in the preceding paragraph shall be obtained by using the following methods:

- determination of the surface recharge area according to surface morphology of the river basin,
- estimation of geo-hydraulic properties of the water flow through the geological layers,
- determination of hydrogeological boundaries on the basis of stratigraphical, lithological and structural (tectonic) elements acquired by the field mapping and photogrammetric geological surveys,
- determination of catchment area after identifying the origin of groundwater on the basis of assessment of hydro-geochemical units,

- tracer experiments by determining the groundwater flow velocities, dilution and dispersion parameters of pollutants,
- graphic design of external streamlines and isochrones by modelling characteristic external boundary streamlines - the lower culminated points and the theoretical width of the capture, or
- external streamlines planning and planning of isochrones with mathematical modelling.

(3) If the application of the results of only one of the methods described in the preceding paragraph does not provide reliable and efficient determination of borders of inner areas, a combination of more methodologies should be used to determine the border of the inner areas of water protection area**.**

5.4 Safety extension of the boundary of water protected zone for porous aquifer

Water protected area has to be extended in the lateral and longitudinal direction if the intensive study of hydrogeological conditions reflects that:

(i) a part of groundwater runoff from the natural catchment area passes by the depression funnel,

(ii) a part of groundwater runoff from the natural catchment area passes by the capture,

(iii) the gradient of piezometric level changes in various hydrological periods,

(iv) the aquifer transmissivity changes during low groundwater level in dry seasons,

(v) groundwater flow direction changes,

(vi) the aquifer is not homogeneous,

(vii) water flows to the capture from several aquifers, which are situated one over the other, or

(viii) no information is available about the dispersion or they are unreliable.

6. FISSURED AQUIFERS

6.1 Water protection areas determination for fissured aquifers

For determination of protection areas for fissured aquifer, it should be noted that:

(i) The groundwater flow may have similar characteristics as the water flow in porous or karstic aquifer;

(ii) The characteristics of this aquifer are more similar to those of the porous aquifer, if the flow of water through the cracked middle homogeneous is laminar;

(iiI) The characteristics of this aquifer are more similar to those of the karst aquifer, if the water flow is not laminar or if it is running through the middle, which is inhomogeneous cracked.

Inner areas of fissured aquifer are defined according to the characteristics of groundwater flow in a way that is used to define the inner areas of porous or karst aquifer.

7. SURFACE WATERS

Water protection areas depending on the type of surface water bodies for the withdrawal of water are determined in a special way for the **stagnant (still) and flowing water**.

The border of **water protection zone of surface water capture** is determined by the method:

- selected distances,
- isochrones and dilution of pollutants, or
- intervention time.

7.1 Stagnant (still) surface water

For determination of the protection areas for security of stagnant surface water should be noted that:

(i) These waters characterize slow water flow, because on the flow of water surface gradient of the water has no influence;

(ii) The bodies of stagnant surface water have typical average residence time longer than 5 days;

(iii) Quantitative, chemical and ecological status of surface water bodies is heavily dependent on seasonal changes in the hydrometeorological conditions.

7.1.1 Surface water protection zones for the abstraction of stagnant surface water

(1) The border of water protection zones for the abstraction of stagnant surface water (Fig. 3) is determined using the method of selected distance as:

- the Outer area includes the catchment area of the water source,
- the Middle area comprises all flowing waters including riparian zone up to 100 m,
- the Inner area comprises standing water including 100 m of riparian zone at the maximum 100-year water level, and
- the Middle zone extends at least 100 m outside the Inner area.

(2) The border of water protection zones for the abstraction of stagnant surface water using the method of isochrones having regard to the annual high-water is determined by:

- the Outer area includes the catchment area of the water source,
- the Middle area comprises the whole stagnant water, its riparian zone at least 100 m wide, and flowing water, where the flow time until the capture is less or equal to 20 days, including their 100 m riparian zone,
- the Inner area includes the part of the stagnant and flowing waters, where the flow time to capture is less or equal to 10 days, including their 100 m riparian zone at the maximum 100-year water level of standing water and a one-year water level for flowing water,
- the Middle zone extends at least 100 meters outside the Inner area.

(3) The border of a water protection area for the abstraction of stagnant surface water is determined using the intervention time method with calculating the flow rate of water in a one-year high flow and considering the provisions of inner areas of these Rules:

- the Outer area includes the catchment area of the water source,
- the Middle area includes the part of the stagnant and flowing water, where the flow time to capture is less or equal to 48 hours, including the 100 m riparian zone at the maximum 100-year water level of stagnant water and one-year water level for flowing water,
- the Inner area includes the part of the stagnant and flowing water, where the flow time to capture is less or equal to 12 hours, including the 100 m riparian zone at the maximum 100-year water level of stagnant water and a one-year water level for flowing water, and
- the Middle zone extends at least 100 meters outside the Inner area.

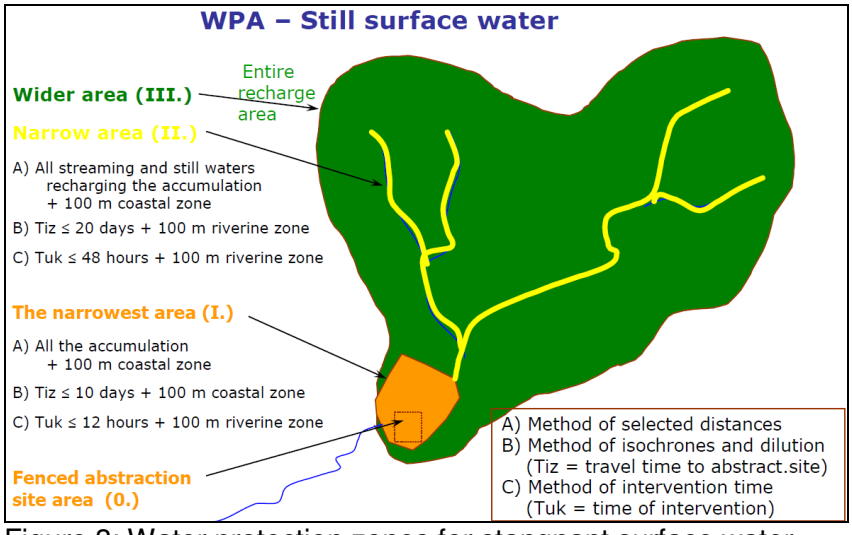

Figure 3: Water protection zones for stangnant surface water.

7.2 Flowing (streaming) surface water

For determination of the protection areas in case of abstraction of flowing surface water bodies should be noted that:

(i) For these waters the longitudinal velocity component is expressed due to the gradient of water levels and on the basis of this velocity isochrones are calculated;

(ii) Quantitative, chemical and ecological status of surface flowing water depends heavily on seasonal changes in the hydrometeorological conditions.

7.2.1 Surface water protection zones for the abstraction of stagnant surface water

(1) The border of water protection zones for the abstraction of flowing surface water (Fig. 4) is determined using the method of selected distance as:

- the Outer area includes the catchment area of the water source,
- the Middle area includes all flowing and stagnant water from which part of the stream with the capture is recharged, including their 100 m riparian zone,
- the Inner area comprises a part of the stream with the capture towards the 15,000 m upstream and 50 m downstream, including the related 100 m riparian zone of the stream at the maximum 100-year return period water level, and
- the Middle zone extends at least 100 meters outside the Inner area.

(2) The border of water protection zones for the abstraction of flowing surface water using the method of isochrones having regard to the annual high-water is determined by:

- the Outer area includes the catchment area of the water source,
- the Middle area comprises a network of surface water flows, for which the flow time to capture is less or equal to 5 days, including 100 m riparian zone,
- the Inner area comprises a part of the stream with the capture, for which upstream flow time to capture is less or equal to 1 day, including their 100 m riparian zone at the maximum 100-year water level, and
- the Middle zone extends at least 100 meters outside the Inner area.

(3) The border of a water protection area for the abstraction of flowing surface water is determined using the intervention time method with calculating the flow rate of water in a one-year high flow and considering the provisions of inner areas of these Rules:

- the Outer area includes the catchment area of the water source,
- the Middle area includes the part of the network of surface water, for which the flow time to capture is less or equal to 12 hours, including the 100 m riparian zone,
- the Inner area comprises a part of the stream with the capture, for which the flow time to the capture is less or equal to 4 hours, but not less than 500 m, including their 100m riparian zone at the maximum 100-year return period water level, and
- the Middle zone extends at least 100 meters outside the Inner area.

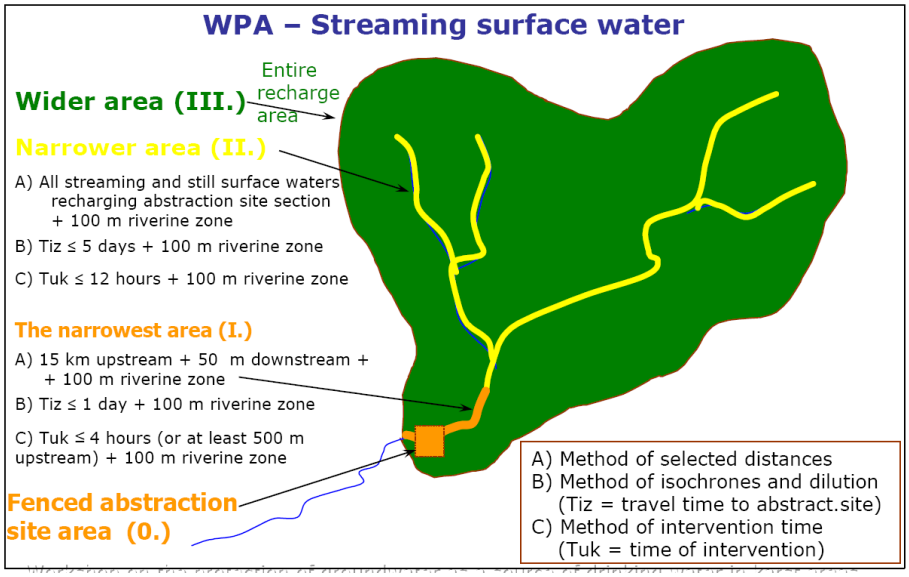

Figure 4: Water protection zones for flowing surface water.

7.3 Protection zones of “special” captures

7.3.1 Systems of different aquifers

(1) If the water flows into the capture from several aquifers, which lie one above the other, it is necessary to assess the quantities of contributing water of individual aquifers by abstraction.

(2) The borders of water protection areas of aquifers, which lie one above the other, must be adapted to capture aquifer, which has the largest catchment area.

7.3.2 Groundwater recharge from surface water

(1) If the water in the capture consists of water from the riparian part of surface water and water from the aquifer, both criteria for determining the boundaries of water protection areas for groundwater and surface water are used.

(2) Water, which naturally recharges the aquifer, must not exceed the quality limits prescribed by the regulations governing the quality of surface water intended for the abstraction of drinking water.

(3) In case that surface water is part of the renewal of groundwater and if the majority of surface water runoff infiltrates into the exploited aquifer, the catchment area of surface water must be included at least in the Outer area.

(4) For the capture of which, due to morphological or geological conditions, water is abstracted after the infiltration from the surface through the aquifer in time that is shorter than 50 days, it is necessary to determine whether the protection measures in the Inner area are sufficient the protection of capture.

7.3.3 Artificial recharge of the aquifer

(1) Water that artificially recharges the aquifer must not exceed the limits prescribed by the regulations governing the quality of surface water intended for the abstraction of drinking water.

(2) The area between the location of artificial recharge and catchment area must be classified in the Inner area where the flow time from recharge area to capture during the intensive supply is less than 50 days.

(3) The facilities of artificial recharge should be the subject to the same water protection regime as the catchment facilities (capture).

(4) The whole area should be fenced in case:

- if the distance between the location of artificial recharge and the capture is less than 50 m

- the aquifer is not covered with continuous geologically very low permeable layers of thickness not less than 5 m or less than 8 m,

- if the flow rate is larger than 10 m/day.

(5) The determination of the boundaries of the Outer area of the aquifer, which is artificially recharged, depends on the quantity and quality of natural groundwater according to the quantity and quality of surface water used for artificial recharge.

7.3.4 Combined captures

(1) In case that water from the aquifer also flows into the capture of surface water, criteria for determining the boundaries of water protection zones for capture of groundwater are also applied (in addition to the criteria for determining the boundaries of water protection area for captures of surface waters).

(2) In case that the capture simultaneously discharges surface and groundwater, the boundaries of water protection areas should be established using the criteria for groundwater and surface water.

8. PLANNING OF PROTECTIVE MEASURES

Protective measures for the facilities constructions and implementation of the construction works, for which it is expected that during the construction and implementation represent a risk for pollution of the water body, must be planned based on the risk analysis, so that the risk of pollution of the water body due to facilities constructions and implementation of the construction works is acceptable. It is considered that the risk of water body pollution is acceptable if it is clearly evident from the results of the risk analysis of the pollution.

The risk analysis for pollution of water bodies is provided by investor of intervention in the environment in the water protection zone.

8.1 Optimization of protective measures

(1) The risk analysis for pollution must be made using the methods of deterministic or probability risk analysis and using the costs analysis caused due to elimination of pollution effects and loss of water supply.

(2) The cost of protective measures should be evaluated with a comparative economic analysis of the costs and benefits of establishing protective measures, taking into account the costs of drinking water treatment, which due to the introduction of protective measures are not necessary.

8.1.1 Deterministic risk analysis

(1) The acceptability of the pollution risk due to the construction of buildings (Annex 1) or of the construction works (Annex 1) is assessed with deterministic risk analysis on the basis of the following criteria:

- the construction of facilities or implementation of the construction works is acceptable, if the change of any parameter that is subject of risk analysis of pollution does not exceed the relative sensitivity of this parameter (Annex 2),
- the construction of the facility or implementation of the construction works is acceptable if a change of any parameter that is subject to risk analysis for pollution, the value of this parameter does not exceed the limit values for this parameter determined by the regulations governing drinking water.

(2) For parameters where the value of relative sensitivity (Annex 2) is not determined, it is considered that the value of the relative sensitivity is +2.

(3) The substances, which were not presented in the water body before the human intervention in the environment, after an intervention should not appear.

(4) The relative sensitivity is the ratio between the observed value of the new state of water due to threat and the reference state and is calculated as follows:

$$S = (R + \Delta R) / R$$

Where *S* is relative sensitivity and *R* is reference condition, which is equal to the average value of the parameter before the intervention in the environment calculated as the arithmetic mean of the analytical results of the monitoring in drinking water capture in the last five years. If the results of analyses are not available for last five years, the state zero state is determined with additional monitoring of potential pollutants in capture, which must include at least two years of measurements with a minimum frequency of sampling six times a year. *ΔR* presents the change in the reference condition because of threats.

8.1.2 Probability risk analysis

(1) The acceptability of the risk of pollution after probability risk analysis is determined on the basis of the probability of the event, which leads to pollution of the water body.

(2) The probability analysis is performed using the criteria and in a way specified by deterministic risk analysis.

(3) Probabilistic risk analysis is carried out if:

- the probability of an event exceed 10^{-2} per year and the capture supply less than 1,000 inhabitants,
- the probability of an event exceed 10^{-3} per year and the capture supply more than 1,000 inhabitants,
- the probability of an event exceed 10^{-4} per year and the capture supply more than 10,000 inhabitants, or
- the probability of an event exceed 10^{-5} per year and the capture supply more than 100,000 residents.

(4) The risk of pollution of the water body is due to the facility construction within the protection zone based on probability risk analysis acceptable if the relative sensitivity is less than permissible value from Annex 2.

(5) Probability risk analysis should take into account also the risk of pollution from already implemented environmental interventions within the water protection zone.

8.2 The extent and content of risk analysis

(1) Risk analysis of pollution due to the construction of the object in the water protection area includes:

- A description of the risk and the definition of impact scenarios on water source:

  - determination of the number and types of pollutants,
  - definition of the mechanism of the spill and/or release of pollutants,
  - the definition of a scenario of normal and an alternative developments of events and scenario of worst options,

- Identification of pollutants with the assessment:

  - interaction of pollutants and the environment,

- the toxicity of pollutants,
- the mobility of contaminants,
- chemical properties and the amount of pollutants,

- Characteristics of the catchment:

- the description of the capture method,
- estimate the amount of captured water,
- the description of the regime and the dynamics of water resources exploitation,

- The definition of a water source:

- assessment of the state, which is a summary review of the natural background and load in the water source,
- evaluation of the natural background,
- load of the water source,
- the description of the natural characteristics of the water source,

- Definition of transport ways of pollutants from the source of threat to the capture,

- Calculation of the transport of pollutants in relation to the different scenarios,

- Definition of risk for pollution.

(2) Calculation of the pollutants transport has to demonstrate:

- the starting point for the selection of calculation methods,
- verifiability and repeatability of the methods of calculation,
- comparability of the calculation method with other methods, and
- reliability of calculation methods.

(3) When calculating the pollutants transport sensitivity analysis should be carried out that demonstrates the reliability of calculation model. Sensitivity analysis is performed for key parameters of the pollutants transport calculations.

8.3 The revision of risk analysis for pollution

Revision of project documentation is an integral part of the risk analysis for pollution, which checks the impeccability and calculation correctness of the risk analysis.

The revision of documentation shell engage by legal or other person who fulfils the conditions prescribed for revisers according to the construction regulations.

The revision of risk analysis for pollution may carry out also the higher education or other institution that conducts research or educational activities relating to the water resources protection if it has been entered in the register of the activities related to the technical consulting and employees meet the prescribed conditions for responsible reviser according to regulations governing construction.

9 References

Pravilnik o kriterijih za določitev vodovarstvenega območja (Rules on criteria for the designation of a water protection zone), 2004. Official gazette of republic of Slovenia No. 64/2004, 5/2006, 58/2011, 15/2016. Online available: http://www.pisrs.si/Pis.web/pregledPredpisa?id=PRAV1024 (15.5.2016)

Annex 1

List of protection measures in Protection Zones implemented according to the "Rules on Criteria for the Designation of a Water Protection Zone" in Slovenia

DWELLING HOUSES	WPZ I	WPZ II	WPZ III
Single-residence building	-	pd[1]	+[3]
Residential buildings	-	pd[1]	+[3]
Residential buildings for special purposes	-	pd[1]	+[3]

NON-RESIDENTAL BUILDINGS	WPZ I	WPZ II	WPZ III
Lodging houses and restaurants	-	pd[1]	+
Office houses	-	pd[1]	+
Buildings for commerce	-	pd[1]	+
Fair and trade buildings, exhibition grounds	-	pip	+
Petrol and gas stations	-	pip	pip
Buildings for other service activities	-	pd	+
Stations, terminals, buildings for electronic communications, and related buildings	-	pd[6]	pd[10]
Garage buildings	-	pp	pd[3]
Industrial buildings	-	pp	pp
Tanks, silos	-	-	pp
Warehouses for non-dangerous goods	-	pp	pd[1]
Cultural and entertainment buildings	-	pd[1]	+
Museums and libraries	-	pd[1]	+
Buildings for education, research, and development	-	pd[1]	+
Medical buildings	-	pp	pd
Sports halls	-	pd[1]	+
Buildings for plant harvesting	-	pp	pp
Stockbreeding buildings	-	-	pp
Harvest warehouses	-	pd[1]	+
Other non-dwelling farming buildings	-	pd[1]	+
Buildings for religious services	-	pd[1]	+
Cemetery buildings and accompanying constructions	-	pd[1]	pd
Cultural monuments	+	+	+
Other non-dwelling buildings not listed	-	pd[1]	+

TRANSPORT INFRASTRUCTURE	WPZ I	WPZ II	WPZ III
Highways, expressways, major roads, regional roads	pip[2]	pd[2]	pd
Local roads, public roads, non-categorized roads, forest roads except parking lots	pip	+	+

Parking lots	-	pp[2]	pd[2]
Main and regional railroads	pip[9]	pip[9]	pip
Municipal railroads	-	pip[9]	pip
Airport runways and platforms	-	-	pip[2]
Airport communication services – navigation buildings	-	+	+
Bridges and crossings	pip	pd	pd
Tunnels and cuttings	-	pip	pd
Harbours and navigable channels	-	pd	pd
Dams and levees	pd	pd[2,9]	pd
Conducting channels, irrigation channels, drainage channels	-	pp	+

COMPLEX INDUSTRIAL INFRASTRUCTURE	WPZ I	WPZ II	WPZ III
Mining infrastructure	-	-	pip
Buildings for energy management and production	-	pip	pp
Chemical industry infrastructure	-	-	pp
Facilities that can cause large pollution as defined by environmental legislation	-	pp	pp
Production facilities representing risk of possible large scale accidents with dangerous chemicals as defined by environmental legislation	-	pp	pp
Other complex industrial infrastructures not listed	-	-	pip

OTHER CIVIL ENGINEERING CONSTRUCTIONS	WPZ I	WPZ II	WPZ III
Sport places	-	pp	pd
Other civil engineering constructions for sport, sport recreation, and spare time	-	pp	+
Military buildings	-	-	pip
Flood prevention facilities	pip	pip	pd
Landfills and facilities for recycling of dangerous goods	-	-	-
Non-dangerous and inert goods collection facilities	-	-	pp
Cemeteries	-	-	pp
Other civil engineering constructions not listed	-	pp	pd

INFILTRATION STRUCTURES	WPZ I	WPZ II	WPZ III
Groundwater infiltration from one aquifer to another without detected anthropogenic influences	-	pp	pp
Infiltration structure for treated municipal waste water – infiltration through soil covered with vegetation	-	pip[13]	pp[13]
Infiltration structure for treated technological waste water – with a biologically active treatment layer	-	pip[13]	pp[13]
Infiltration of treated rainfall water from paved surfaces	-	pp[13]	pp[13]

INFILTRATION STRUCTURES	WPZ I	WPZ II	WPZ III
Infiltration of precipitation collected on roofs	pd	+	+

CONSTRUCTION WORKS	WPZ I	WPZ II	WPZ III
Construction sites in accordance with construction regulations with a surface not larger than 1 ha	-	pp	pd
Parking places on construction sites for building engines and facilities (without maintenance)	-	pd	+
Maintenance places for building engines and temporary storage facilities for fuels, lubricant oils, and chemicals used in construction	-	pd	+
Construction site toilets	-[12]	-[12]	-[12]
Temporary storage places for elements made of concrete	-	pd	+
Fuel supply for engines and machines on construction sites (fuel decantation)	-	pp	+
Construction site excavation	pd	pd[5]	+[5]
Use and cleaning on construction site of facilities for concrete production, geotechnical facilities, and milling machines	-	pd	+[2]
Shot concrete use	-	pp	+
Waste construction material use	-	pp	+
Recyclable construction material use	-	pp	+
Construction material use with possible leakage of water pollutants	-	-	-
Cleaning and treatment of building surfaces or construction materials where waste water is present (e.g. building front)	-	+	+
Land surface morphology changes with soil embankment construction or soil removal	-	pp	pd
Sealing barriers for water resource protection	pp	pp	pd
Sealing barriers for other uses	-	-	pp
Construction material injection	-	pd[4]	+
Drilling and hammering wood and concrete piles	pp	pd	pd
Drilling without drilling fluids, except for water resource investigation	-	pp	pd
Drilling with drilling fluids	-	-	pd
Drilling – filling of annulus space	+	+	+
Drilling for geothermal energy exploitation – heat exchangers in closed system	pp	pp	pp
Drilling for geothermal energy exploitation – heat exchangers in open system	-	pd	pd
Drilling with biodegradable drilling fluids	pp	+	+

CONSTRUCTION WORKS	WPZ I	WPZ II	WPZ III
Drilling for other uses	-	pd	pd

CONSTRUCTION OF SIMPLE CIVIL ENGINEERING FACILITIES	WPZ I	WPZ II	WPZ III
Auxiliary buildings for private use			
Woodsheds, projecting roofs, sheds, huts	+	+	+
Garages, hotbeds, pools	pd	+	+
Auxiliary infrastructures			
Auxiliary road buildings except water drainage infrastructure and toll houses Auxiliary railroad buildings except water drainage infrastructure Auxiliary cable car buildings Auxiliary buildings for energy production and manipulation except transformers Auxiliary communal buildings except small standardised waste water treatment systems	pd	+	+
Road drainage, toll houses, railway tracks drainage, power supply transformer stations, small typified waste water treatment systems, municipal waste fraction collection sites, airport auxiliary buildings, border crossing auxiliary buildings	-	pd	+[13]
Auxiliary buildings for agriculture and forestry			
Apiaries, forest trails, forest roads, forest sledges, forestry education tracks, forestry cable cars, granaries, hay racks, farm sheds, cart tracks, barns	+	+	+
Dunghills, cesspools[23] up to 150 m^3, greenhouses, fish ponds	-	pd[14]	+
Temporary buildings intended for tourist season activities, tourists arrangements, and warehousing	-	pd	+
Sport grounds and recreational grounds except golf courses			
Sport grounds and recreational grounds, bicycle tracks, mountain paths, walking tracks, promenades, ski slopes[21], parachute and hang-glider runways	pp	+	+
Piers, rifle ranges	-	pd	+
National defence training buildings, training buildings for civil defence, emergency help, and emergency services	-	pd	+
Monuments	+	+	+

CONSTRUCTION OF SIMPLE CIVIL ENGINEERING FACILITIES	WPZ I	WPZ II	WPZ III
Urban equipment			
Stopping places, public bicycle sheds, public telephone boxes, advertisement pillars, stands, sculptures, art installations, multipurpose stands, prefabricated sanitary units, fountains	+	+	+

FERTILIZATION	WPZ I	WPZ II	WPZ III
Fertilization without plan	-	-	-
Fertilization with animal manure and artificial fertilizer	-	+[18]	+[17]
Production of farming plants based on the programme prepared for drinking water Protection Zones without application of artificial fertilizers, liquid manure, or manure deposited for less than six months	+[18]	+	+
Grass tillage	-	+[18]	+[18]
Temporary deposition of manure on the field (more than 1 m^3 altogether)	-	-	+
Temporary deposition of compost on the field except Class I compost (more than 1 m^3 altogether)	-	-	+
Manure use in garden and forestry plantations	-	+[17]	+
Manure and liquid manure in forest use in parks and sport grounds	-	-	-
Liquid manure use on farms, gardens, and forestry plantations	-	+[18]	+[17]
Treatment plants waste mud use on farms, gardens, and forestry plantations	-	-	-
Treatment plants waste mud use in forests, parks, and sport grounds	-	-	-
Artificial fertilizers use in garden and forestry plantations	-	+[18]	+[17]
Artificial fertilizers use in forests, parks, and sports grounds	-	+[18]	+[17]
Compost use on farms, gardens, and forestry plantations, except 1. class compost	-	-	-
Compost use in forests, parks, and sport grounds, except 1. class compost	-	-	-
Manuring with remains from closed cesspits, lavatories, and sewage systems	-	-	-
Manuring of gardens on construction sites, kitchen gardens on agricultural areas, and other empty lands	-	-	+[17]

PLANT AND WOOD PROTECTION AGENTS USE	WPZ I	WPZ II	WPZ III
Use of phytopharmaceutical agents not intended to be applied in drinking water Protection Zones	-	-	-
Use of phytopharmaceutical agents intended to be applied in drinking water Protection Zones in farms, gardens, and forestry plantations	-	+[22]	+
Use of phytopharmaceutical agents intended to be applied in drinking water Protection Zones in gardens on construction sites, kitchen gardens on agricultural areas, and other empty lands	-	-	+
Use of phytopharmaceutical agents intended to be applied in drinking water Protection Zones in parks, forests, cemeteries, and sports grounds	-	+[22]	+
Use of phytopharmaceutical agents intended to be applied in drinking water Protection Zones for transport infrastructure	-	pd[20]	+[20]
Use of phytopharmaceutical agents intended to be applied in drinking water Protection Zones for the railway tracks	-	pd[16]	+[16]
Wood protection agents intended to be applied in drinking water Protection Zones	-	-	+[11]

FORESTRY	WPZ I	WPZ II	WPZIII
Total cutting down of trees	-	-	+
Afforestation	+	+	+

Explanation of abbreviations, signs, and numbers in superscripts:

* In karstic aquifers and fissured aquifers with the characteristics of karstic aquifers where intervention in the Outer protection zone can influence conditions in the Middle Protection Zone, protection measures that are valid for the Middle Protection Zone must be implemented. The same requirement is valid for the relation between the Inner and Middle Protection Zones.

pd[1] – In the Middle Protection Zone it is prohibited to diminish the volume of the aquifer or intersect the groundwater flow or to diminish the protection layer above the aquifer by construction of any building or other civil engineering structure.

pip[2], pp[2], pd[2], +[2] – Protection measures consist of specially designed sealing layers, an uplifted rim of the working area, and diversion of water away from the protection Zone.

+[3], pd[3] – In the Outer Protection Zone buildings and facilities must be constructed 2 m above maximum groundwater level. An exception is allowed if the construction does not

diminish aquifer transmissivity by more than 10%. If during the construction and later operational period, groundwater drainage, or pumping is needed, water consent based on Water Law requirements must be acquired.

pd[4] – Allowed only in the case when landsliding is stabilized.

+[5], pd[5] – Excavations are allowed if the bottom of the pit is higher than 2 m above maximum groundwater level.

pip[6] – In the Middle Protection Zone, construction of cisterns standing in open air used for water treatment with accompanying pipelines and decantation places is allowed; cisterns with a volume of 450 l in a shelter building are allowed; cisterns for crude oil standing in open air with accompanying pipelines and decantation places are allowed if the volume of each storage place is up to 30 m^3; an expert survey must be conducted every second year.

pd[7] – The internal sewerage network must be connected with the public sewerage system. Before the implementation of the internal sewerage system, water tightness must be tested with standard procedures.

pd[7,8] – The internal sewerage network must be connected with the public sewerage system. Before the implementation of the internal sewerage system, water tightness must be tested with the standardized procedures. Water tightness of the public sewerage system must be tested with the standardized procedures.

pip[9] – Railway must be constructed on the sealing layer; all meteoric water must be diverted away from the Protection Zone.

pd[10] – When coach wagons with cisterns for dangerous goods are present in railway stations, special protection measures must be applied.

+[11] – Wood protection agents are allowed in buildings that are constructed for preventing leakage and infiltration into the groundwater or into the water capture facility.

-[12] – Chemical toilet or drainage into the sewerage system is allowed.

pd[13], pip[13], pp[13] – It is prohibited to infiltrate treated waste water into the groundwater or drinking water capture facility before diversions into the surface water course. The bottom of the infiltration facility must be higher than 1 m above maximum groundwater level; encroachment into the groundwater is not allowed during construction of the infiltration facility.

pd[14] – The bottom of the dunghill or cesspit must be higher than 2 m above maximum groundwater level. All constructions must be watertight.

[15] – The bottom of the mineral resources excavation pit must be higher than 2 m above the estimated maximum groundwater level based on the last 10 years of observations.

pd[16], +[16] – Phytopharmaceutical agent application is allowed in accordance with the legal rules defining cooperation of possessors in removing harmful organisms on railway structures.

+[17] – Phytopharmaceutical agent application is allowed if limit values of nitrogen are in accordance with legal rules defining the introduction of dangerous substances and plant nutrients into soil.

+[18] – Allowed in accordance with legal rules defining the introduction of dangerous substances and plant nutrients into soil if it follows from the qualitative monitoring during the last five years that groundwater has good chemical status in accordance with legal rules defining the chemical status of groundwater and none of the annual average values of nitrogen concentration are larger than 10 mg/l.

+[19] – Allowed if 1. class compost is used in accordance with the legal rules defining the introduction of dangerous substances and plant nutrients into soil.

pd[20], +[20] – Phytopharmaceutical agent application is allowed if done in accordance with the legal rules defining liable cooperation of owners in removing harmful organisms on railway structures.

[21] – In Inner Protection Zones, ski slopes are not allowed. On existing ski slopes, the use of snow stabilizing agent is prohibited.

+[22] – Allowed only on intergranular porosity aquifers and on fissured porosity aquifers with the characteristics of karstic aquifer Protection Zones.

[23] – Reconstruction of existing dunghills and cesspits, and, exceptionally, construction of new ones, is allowed as a sanitation measure for existing farm husbandry. The bottom of the dunghill and cesspit must be at least 2 m higher than the maximum groundwater level. All structures must be watertight.

Annex 2

Permissible values of relative sensitivity

Perameter	Unit	Expressed as	The limit of detection (LOD)	Relative sensitivity A	Relative sensitivity B
pH			0.1	–	–
Conductivity	µS/cm		1	+1.25	–
Oxygen	mg/l	O_2	0.5	-1.5	–
OTHER PARAMETERS					
Colour	m^{-1}		0.1	2	–
Turbidity	mg/l		0.5	+2	–
TOC	µg/l	C	0.2	+2	+1.5
AOX	mg/l	Cl	2	+2	+1.5
Ammonium	mg/l	NH4	0.02	+3	+2
Sodium	mg/l	Na	0.1	+2	+1.5
Potassium	mg/l	K	0.1	+2	+1.5
Calcium	mg/l	Ca	1	+2	+1.5
Magnesium	mg/l	Mg	1	+2	+1.5
Iron	µg/l	Fe	10	+4	+2.5
Hydrogen carbonates	mg/l	HCO_3	1	+2	+1.5
Nitrates	mg/l	NO_3	0.1	+2	+1.5
Sulphates	mg/l	SO_4	0.5	+2	+1.5
Chlorides	mg/l	Cl	0.5	+2	+1.5
Orthophosphates	mg/l	PO_4	0.01	+2	+1.5
Boron	mg/l	B	0.02	+2	+1.5
INDICATIVE PARAMETERS					
Nitrites	mg/l	NO_2	0.01	+3	+2
Fluorides	mg/l	F	0.05	+3	+2
Cyanides	µg/l	CN		+3	+2
Sulphides	mg/l	S		+3	+2
Aluminium	µg/l	Al	10	+4	+2.5
Antimony	µg/l	Sb		+4	+2
Arsenic	µg/l	As	2	+4	+2
Cooper	µg/l	Cu	1	+4	+2
Barium	µg/l	Ba		+4	+2
Beryllium	µg/l	Be		+4	+2
Zinc	µg/l	Zn	5	+4	+2
Cadmium	µg/l	Cd	0.1	+4	+2
Cobalt	µg/l	Co		+4	+2
Tin	µg/l	Sn		+4	+2

Chromium (total)	µg/l	Cr	1	+4	+2
Chromium (6+)	µg/l	Cr^{6+}	5	+4	+2
Manganese	µg/l	Mn	2	+4	+2.5
Molybdenum	µg/l	Mo		+4	+2
Nickel	µg/l	Ni	1	+4	+2
Selenium	µg/l	Se		+4	+2
Silver	µg/l	Ag		+4	+2
Lead	µg/l	Pb	1	+4	+2
Thallium	µg/l	Tl		+4	+2
Titanium	µg/l	Ti		+4	+2
Tellurium	µg/l	Te		+4	+2
Vanadium	µg/l	V		+4	+2
Mercury	µg/l	Hg	0.1	–	+2
Mineral oils	µg/l		5	+2	+1.5
Phenolic substances	µg/l	C_6H_5OH	1	+1.5	+1.5
volatile chlorinated hydrocarbons-LKCH	µg/l			+3	+1.5
Tetrachloromethane	µg/l		0.5	–	+1.5
1,2-Dichloroethan	µg/l		0.5	–	+1.5
1,1-Dichloroethen	µg/l		0.5	–	+1.5
Trichloroethen	µg/l		0.5	–	+1.5
Tetrachloroethen	µg/l		0.5	–	+1.5
Volatile aromatic hydrocarbons-BTX	µg/l			+3	+1.5
Polychlorinated biphenyls-PCB	µg/l		0.005*	+4	+1.5
Polycyclic aromatic hydrocarbons-PAH	µg/l		0.04	+3	+1.5
Phytopharmaceutic substances**					
The sum of active substances and their degradation compounds from the rules on monitoring of surface water chemical status	µg/l			+3	+1.5
Other phytopharmaceutic products covered Rules on the	µg/l		Values from Regulation	–	+2

monitoring of chemical status of surface waters					
The sum of active substances and their degradation compounds from the Rules of the emission monitoring groundwater	µg/l			+3	+1.5
Other phytopharmaceutic products covered Rules on emission monitoring of groundwater	µg/l		Values from Regulation	–	+2

* Applies to single isomer

** For deterministic risk analysis as phytopharmaceutic products under this Regulation considered pesticides and their metabolites (degradation compounds) from the regulations that determine the chemical status of surface water and groundwater quality.

A: Relative sensitivity applies to the results of the deterministic risk analysis, which

value is lower than five times of the limit

B: Relative sensitivity applies to the results of the deterministic risk analysis, which

value is greater than five times of the limit

Slovenian Rules on criteria for the designation of a water protection zone - Ljubljana, May 2015

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