Reduction of water pollution in salt marshes through biotechnical measures

Case study

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SUMMARY

The salt marshes of Southern Moravia are unique ecosystems characterised by high salinity of soils and water. In the Czech Republic, they occur mainly in the geomorphological area "Dolnomoravský úval", where conditions are influenced by both the geological subsoil and the historical hydrology of the area. Currently, most wetlands and salt marshes are endangered by significant degradation, mainly due to inappropriate agricultural practices, land drainage and regulation of watercourses. These changes are leading to a dramatic loss of biodiversity and deterioration of the ecological functions of these habitats. Inland salt marshes are one of the most threatened habitats in Europe.

The LIFE in Salt Marshes project focuses on the ecological restoration of degraded inland salt marshes in the Moravian region of the Czech Republic. The project, funded by the LIFE Programme of the European Commission, aims to restore these wetlands through a combination of traditional and innovative management techniques. The aim of this study was to assess the water regime of the areas of interest, the water quality of the saline areas themselves and their tributaries, and to identify sources of water pollution. The output of this study is a conceptual proposal for an appropriate system of measures to improve water quality and stabilise the water regime. The practical application is the subsequent implementation of four of these proposed measures in practice.

The results of the study showed that the water quality in the South Moravian salt marshes is threatened by several different sources of pollution. The communal (point) pollution of some sites is evidenced in particular by high concentrations of ammonium ions, phosphorus and very high concentrations of glyphosate and its metabolite AMPA (Bílovický stream in the Trkmanec - Rybníčky EVL, Vrbovecký stream in the Vrbovecký pond EVL and the pond in the Dobré Pole EVL. In addition to the intensification of the Wastewater treat plants itself, the elimination of pollutant inputs mainly consists of the revitalisation of the streams concerned to enhance their self-cleaning capacity and the implementation of appropriate biotechnical measures such as artificial wetlands or root treatment.

Agricultural (non-point) pollution occurs only in some locations, in particular in the pool in the Vrbovecký Pond EVL, which is polluted with pesticides, the Bílovický steram in the Trkmanec - Rybníčky EVL, which flows through intensively cultivated landscapes and partly in the Hevlínské jezero EVL. In addition to the revitalisation of the stream, it is advisable to use protective grassing of agriculturally vulnerable sites.

Water quality in other locations is particularly affected by large water bodies with exceptionally large contributing areas. These are the EVL Kosteliska (connected with the Jarohněvický pond) and the EVL Husí pastviště (hydrologically directly connected with the confluence of the Svratka and Jihlava rivers and the Middle Reservoir of Nové Mlýny). In this case, water quality needs to be addressed at the regional level, in particular by implementing measures of a general nature throughout the whole river basin at the regional or national level, e.g. by implementing

the "Water Framework Directive". On a local scale, water pollution in pools can be addressed by removing excess biomass, e.g. by grazing.

In the pools of all sites monitored, very high concentrations of organic carbon from large amounts of dead biomass were detected. Improvement of water quality in these sites is possible mainly by removing excess biomass through appropriate management, e.g. grazing.

Based on the results of the site analysis and field surveys both on the ground and with the help of DZP, systems of measures were proposed in suitable locations to improve the water regime of the sites of interest, reduce the input of pollutants into the saline areas themselves and generally improve the water quality in the areas under consideration. A total of 51 measures have been proposed, 9 of which are point measures, mainly consisting of two biofilters to reduce the load of water flowing into the site of interest and distribution and control structures. Of the linear measures, 19 were proposed, the majority are revitalisation measures on small watercourses and drainage channels. These consist mainly of the milling and cleaning of these watercourses, in suitable locations, including the alteration of directional conditions. A total of 24 area-based measures were proposed, most of which were aimed at changing land use affecting the water quality of the sites of interest. Other measures were in the form of artificial wetlands to improve water quality.

The aim of the proposals was to improve the ecological status of areas of interest. The author's team sought to design workable systems of measures regardless of their feasibility within the Life In Salt Marshes project. During the course of the project, the aim is to implement 4 measures and then evaluate their effectiveness. Additional measures will be recommended for implementation as part of public funding and follow-on projects.

1. INTRODUCTION

The salt marshes of southern Moravia represent unique ecosystems characterised by a high content of mineral salts in both soil and water. Within the Czech Republic, they are primarily found in the Lower Morava Valley, where their occurrence is influenced by both the geological substrate and the region's historical hydrology. These wetlands have formed as a result of the presence of Tertiary marine sediments, from which mineral-rich springs emerge or, more commonly, due to capillary rise of saline water from the subsoil driven by high evaporation. Both of these processes sustain long-term elevated salinity in these areas. Salt marshes typically exhibit a periodic character—during dry periods, they undergo pronounced desiccation, whereas in wetter seasons, they may become partially flooded. The natural processes of salinisation, together with the specific regional climate (high evapotranspiration and lower precipitation), give rise to rare inland salt habitats and saline steppe ecosystems—an extraordinary phenomenon in Central Europe.

Wetlands and saline habitats are essential components of the agricultural landscape, providing key ecosystem services. These include, in particular, the ability to retain water and nutrients in the landscape, thereby contributing to the restoration of the so-called small water cycle. This not only reduces flood risk, but also cools the surrounding environment and promotes more stable microclimatic conditions (Kołos & Banaszuk, 2018). Wetland areas also function as important biocentres and biocorridors within predominantly intensively farmed agricultural landscapes (Deák et al., 2014). Saline habitats, as a specific wetland type, provide critical habitat for rare and often specialised plant and animal species, many of which are on the brink of extinction in both the Czech Republic and across Europe (Horák & Šafářová, 2015; Natlandsmyr & Hjelle, 2016). The regulatory functions of wetlands particularly include climate moderation and water quality improvement. Beyond their hydrological and biological significance, wetlands are also of high aesthetic and productive value, having served for centuries as sources of forage and as sites supporting traditional agricultural practices. Wetlands are thus an irreplaceable and essential part of terrestrial ecosystems (Liu et al., 2018).

At present, most wetlands and saline habitats are experiencing significant degradation, primarily due to unsustainable agricultural practices, land drainage, landscape drying, and watercourse regulation (Tälle et al., 2015; Sychra et al., 2022). These changes have led to dramatic losses in biodiversity and deterioration of ecological functions. Inland salt marshes are among the most endangered habitats in Europe (Gajdoš et al., 2019), especially those subject to periodic desiccation (Calhoun et al., 2017). Soil moisture and organic matter content largely determine plant composition and biomass production (Eneyew & Assefa, 2021), and changes in soil water content strongly correlate with shifts in vegetation structure (Gerdol et al., 2018). Other key factors associated with changes in wetland hydrology include salinity and soil conductivity, both of which fundamentally influence plant diversity in wetlands (Gerdol et al., 2018; Wang et al., 2023; Song et al., 2023). Excessive drying of waterlogged habitats also alters the physical and chemical properties of soils (e.g. subsidence), which may then lead to rainwater accumulation rather than natural groundwater level oscillation. This further reduces salinity, causes the retreat of halophytic vegetation, and results in overgrowth by common, ruderal, expansive, or non-native species. Expansive plants (e.g. Phragmites australis, Calamagrostis epigejos) and invasive alien species (e.g. Solidago gigantea, Solidago canadensis, Symphyotrichum novi-belgii agg.) produce large amounts of biomass that, once decomposed under aerobic conditions, accelerate microbial breakdown and release dissolved organic carbon (DOC) and nitrogen compounds (NO_3^-, NH_4^+) into both soil and water. This contamination (Ye et al., 2024) contributes to water turbidity (DOC increases water colour and reduces clarity), hypoxia (biomass decomposition consumes oxygen, potentially causing its depletion and affecting aquatic life), and increased eutrophication (elevated nitrogen and carbon levels promote algal and cyanobacterial growth). Additionally, nutrient-rich altered wetland soils may act as nutrient sources for surface water transport (Tiemeyer et al., 2006).

To this endogenous contamination driven by altered hydrological conditions, further anthropogenic pollution is often added, introducing excess nutrients and pesticides into wetland systems. Intensive agriculture contributes primarily nitrate nitrogen through subsurface (mainly tile drain) flow (Tomer et al., 2010; Fučík et al., 2017), and total phosphorus via surface (erosive) runoff. Subsurface flow is also a significant source of pesticides and their metabolites in water (Zajíček et al., 2018; Sandin et al., 2018). This form of flow is especially relevant in small, intensively drained agricultural catchments (Holvoet et al., 2007; Brown & van Beinum, 2009). Pesticide concentrations are often significantly higher in small watercourses than in larger streams (Szöcs et al., 2017; Halbach et al., 2021). Drainage water from intensively cultivated fields frequently contains elevated levels of pesticides or their metabolites, which are transported into surface waters (Brown & van Beinum, 2009; Vymazal & Březinová, 2015; Fučík, Zajíček et al., 2017; Zajíček et al., 2015). Other pollution sources include point discharges such as outlets from agricultural (e.g. livestock watering systems, manure storage) or industrial facilities. Wastewater treatment plants (WWTPs) may represent significant point sources of contamination, especially if poorly operated or undersized relative to influent loads. In such cases, ammonium ions and glyphosate or its metabolite AMPA may enter salt marsh waters (Schwientek et al., 2024).

Protecting the hydrological regime of salt marshes is complex, as excessive drying, biomass overgrowth, and even permanent inundation (formation of permanent pools) may lead to further degradation (Sychra et al., 2021). Likewise, surface water inflow can reduce salinity. Sustaining inland salt marshes requires a long-term management strategy combining traditional and innovative practices, such as mowing, grazing, and control of expansive and invasive species (Van Diggelen et al., 2006; Pfadenhauer & Grootjans, 1999). Maintaining an open habitat structure is crucial for conserving their natural functions, hence emphasis is placed on measures that prevent succession, including mechanical maintenance and managed grazing (Prach, 1996; Hejduk et al., 2017).

The LIFE in Salt Marshes project aims to halt the degradation of these habitats and ensure their long-term sustainability through a combination of traditional and innovative ecological management approaches. The project focuses on the comprehensive revitalisation and restoration of 506 hectares of wetlands, including 20 hectares of inland salt meadows—a priority habitat type threatened both nationally and across Europe. Measures combine management practices with nature-based bioengineering solutions to restore natural hydrological regimes, reduce climate vulnerability, and support populations of target species such as Cirsium eriophorum, Ichthyosaura alpestris, Bombina bombina, Rana arvalis, Anas querquedula, and Tringa totanus (Horák & Šafářová, 2015; Natlandsmyr & Hjelle, 2016).

The aim of this study is to assess the hydrological regime of the targeted areas, water quality in salt marshes and their tributaries, and identify sources of pollution. The output of the study is a conceptual proposal of suitable intervention systems aimed at improving water quality and stabilising the water regime. Four of the proposed measures are intended for practical implementation.

2. PROJECT SITES

The project includes specific sites in the South Moravian Region selected for their ecological value and the presence of priority habitats. Each site is characterized by unique natural conditions and varying degrees of degradation, requiring tailored approaches to their restoration and protection. Within the framework of the LIFE in Salt Marshes project, which focuses on the conservation of critically endangered salt marshes in Moravian Pannonia, a total of ten pilot sites in the South Moravian Region have been selected. These are Sites of Community Importance (SCI) included in the Natura 2000 network, in which salt marsh habitats occur in various stages of preservation or degradation. The spatial distribution of the project sites is shown in Figure 1. The project aims to achieve the comprehensive revitalization and restoration of 506 hectares of wetlands, including 20 hectares of inland salt meadows – a priority habitat threatened at both national and European levels – through a combination of management and nature-based biotechnical measures. These measures are designed to restore the natural hydrological regime of the sites, reduce their vulnerability to climate change, and strengthen populations of target species such as the yellow-thistle (Cirsium eriophorum), Alpine newt (Ichthyosaura alpestris), fire-bellied toad (Bombina bombina), moor frog (Rana arvalis), garganey (Anas querquedula), and common redshank (Tringa totanus), all of which are critically endangered in the Czech Republic and throughout Europe (Horák & Šafářová, 2015; Natlandsmyr & Hjelle, 2016). The basic characteristics of the project sites and their contributing catchments are summarized in Table 1. A detailed description of each site is provided in Chapter 4 of this study. The exact location is shown in annex (10.1. APPENDICES – MAP DOCUMENTATION).

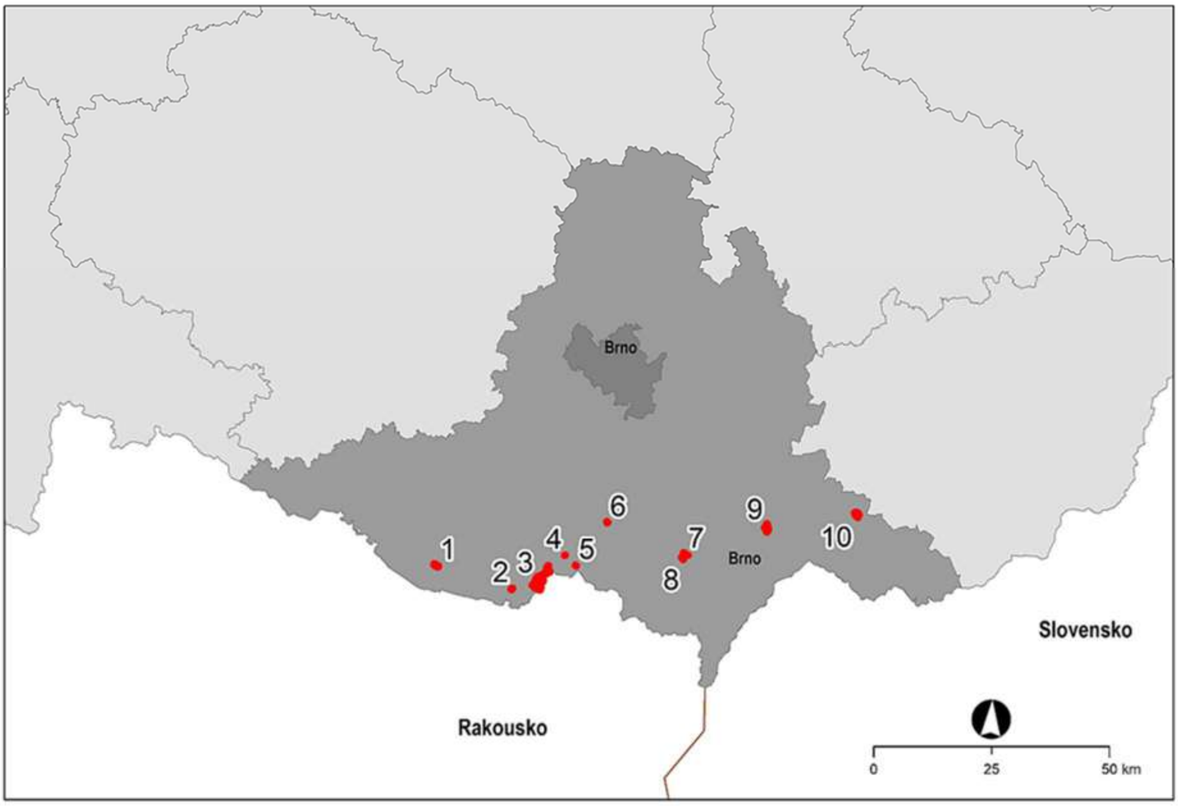

Figure 1: Overview map of pilot site locations. 1 – SAC Vrbovecký rybník; 2 – SAC Hevlínské jezero; 3 – SAC Trávní dvůr; 4 – SAC Slanisko Novosedly; 5 – SCI Slanisko Dobré Pole; 6 – Husí pastviště; 7 – SAC Trkmanec – rybníčky; 8 – SAC Trkmanské louky; 9 – Ptačí park Kosteliska; 10 – SAC Vypálenky

Table 1: Basic characteristics of the pilot sites

	Basic Data		Agricultural Land		Agricultural Drainage		Point Sources
Site	**SCI / SAC Area (ha)**	**Catchment Area (ha)**	**Total (%)**	**Arable (%)**	**ZVHS* (ha)**	**confirmed by remote sensing**	**wastewater treatment plant outfall**
Kosteliska	64,7	32 833,3	48,4	41,4	1 862,1	no	yes
Dobré Pole	3,7	35,9	34,1	32,5	0,0	no	yes
Novosedly	2,1	106,2	35,1	15,6	0,0	no	no
Hevlínské jezero	9,4	25,1	50,9	50,9	0,0	no	no
Trkmanské louky	19,0	183,6	81,4	81,4	58,0	yes	no
Trkmanec-Rybníčky	44,3	1 689,6	69,1	43,9	494,4	yes	yes
Trávní dvůr	257,3	5 348,8	78,6	70,8	149,7	yes	yes
Vypálenky	65,3	101,4	23,9	3,6	0,0	no	yes
Vrbovecký rybník	37,1	2 498,1	79,2	61,2	85,5	ano	ano

* Former Agricultural Water Management Administration (in Czech ZVHS)

3. METHODOLOGY

3.1. DELINEATION OF CONTRIBUTING AREAS

For each site, the contributing area (catchment, sub-catchment) was delineated based on the assumption that water quality and quantity do not arise solely within the site itself but are influenced by the entire catchment area. The study area was analyzed using the ARC GIS environment with the Spatial Analyst extension. Using the 5G Digital Elevation Model (DEM), detailed contour lines were generated, followed by the application of the Fill – Flow Direction – Flow Accumulation functions to produce detailed flow lines in raster format. Based on this raster, a point shapefile was created, and using the Watershed – Raster to Polygon function, the catchment and, for larger areas, the sub-catchment corresponding to the respective SCI site were generated. A similar method was applied using the Raster to Polygon – Polygon to Line function to generate concentrated flow paths.

3.2. ANALYSIS OF NATURAL CONDITIONS

The analysis of natural conditions was conducted for both the SCI sites and their delineated contributing areas, based on a combination of geological, pedological, geomorphological, and hydrological data, alongside field surveys of the sites.

Geological data for the study sites were sourced from the Czech Geological Survey (ČGS), particularly public map applications. Basic data were retrieved from the Geological Map 1:50,000 (Lite), which displays the geological map of the Czech Republic at a scale of 1:50,000 and includes indexes for the geological map. The application also features a layer of borehole data (database of geologically documented objects), which includes information such as bedrock depth beneath the Quaternary, the Quaternary layers of boreholes, and boreholes without lithological data. The application also includes the Geoscientific Map 1:50,000, which displays geoscientific layers from the GeoČR50 database, including geological, tectonic, sedimentological, and hydrogeological data.

Demek et al., 2006, using publicly available map viewers by ESRI on the ArcGIS server (www.arcgis.com).

Pedological data were sourced from the Soil Service Division of the Research Institute for Soil Protection, using data on Bonited Pedo-Ecological Units (BPEJ), hydrological soil groups, soil retention capacities, and infiltration vulnerability (Janglová et al., 2003) and groundwater vulnerability. Publicly accessible versions of these data are available on the VÚMOP portal.

Hydrological data for the study areas were analyzed based on the Water Management Information System (VODA). This includes the Water Line Networks and River Management data. Data on the main drainage systems (HOZ) were obtained from the Czech Land Survey Office (SPÚ ČR).

3.3. Land Use Analysis – LPIS Data

Land use in the studied areas has a critical influence on water quality. The proportion of arable land in the catchment is a key factor, as an increase in arable land correlates with a higher risk of water contamination (Worrall et al., 2003; Fučík et al., 2015). Data on land use in the catchments of the SCI sites were primarily obtained from the freely available Land Parcel Identification System (LPIS) layers. LPIS is a component of the Integrated Administrative Control System (IACS) and is legislated under European Parliament and Council Regulation (EU) No. 1306/2013, and in the Czech Republic, it is governed by Act No. 252/1997 on agriculture. LPIS is implemented using a Geographic Information System (GIS) and serves as a reference database to verify the data provided in applications for agricultural subsidies. LPIS is primarily based on land use records according to user relationships, including land records, ecological elements, and records of agricultural activities. These data are displayed using color-coded digital orthophotos with a resolution of 12.5 cm, generated through aerial measurement photography. The LPIS system is managed by the Ministry of Agriculture, and the Czech State Agricultural Intervention Fund (SZIF) updates the land use records.

3.4. Agricultural Drainage Infrastructure Analysis

The widespread presence of drainage systems has both positive and negative effects on the landscape, especially in areas where drainage intensity is too high or where drainage is unnecessary or detrimental. Drainage systems function as continuous horizontal preferential pathways within the soil, specifically designed to discharge large amounts of water from the drained area. This significantly accelerates runoff from the landscape, affecting the recipient water regime. Drainage systems are a major contributor to the increased leaching of nitrate nitrogen from agricultural soils. The acceleration of runoff is also correlated with the increased leaching of other substances from the soil. It is well established that drainage systems in the Czech Republic are a significant source of diffuse agricultural pollution, particularly in the form of nitrate nitrogen, pesticides, their metabolites, and soluble forms of phosphorus. Some negative effects on the landscape are also associated with the Main Drainage Systems (HOZ), as the deepening and straightening of the drainage lines affect the runoff process and lower the groundwater level (GWL) in adjacent fields. A significant proportion of these systems are also piped, resulting in the loss of connectivity between watercourses and adjacent lands and the loss of natural filtration and groundwater recharge.

The agricultural drainage infrastructure analysis was based on a combination of several data sources. The foundation of these data is derived from the records of the former Agricultural Water Management Administration (disbanded on 30 June 2012). Some of the data, particularly the detailed drainage system drawings, were digitized between 2003 and 2007. Individual drawings were manually redrawn from project documentation (usually at a scale of 1:1 000/2

000) into maps at a scale of 1:10 000. In this way, the entire territory of the Czech Republic was digitized, preserving the division by districts. The result is several map layers at scales of 1 : 10 000 and 1 : 5 000, which are the basic and basically the only national information layer, even with a number of reservations about its processing, completeness and reliability. This base layer is freely available for download at http://eagri.cz/public/web/mze/farmar/LPIS/data-melioraci/. In terms of Detailed Drainage Structures, the ZV010 Drainage Area layer is particularly relevant, as should be the ZV410 Drainage Outfall and ZV 420 Manholes layers, but these are not available in most districts. The VOC polygon layer is in SHP format, with the construction number and year of construction as attributes. The map layer only delineates the drainage area but it is not possible to locate individual linear drainage detail features from it. The accuracy of this layer is subject to technical possibilities and the time of its creation. Its main shortcomings are clearly presented in Kulhavý el al., 2011. These are mainly shape (sometimes also positional) distortions caused by manual redrawing of the base, as well as outdated content (the layer preserves the state as of 1992). Due to the fact that there is no record of land reclamation and its changes in the field, the geometric and attribute scope of the data is not always complete. Also at risk are areas where two stages of drainage have been built on top of each other - the records usually lack very old drainage systems that were built before the date of establishment of the predecessor of the ZVHS (SMS established on 1 January 1970) and at the interface of districts, where some structures are duplicated.

The documents currently stored in the State District Archives (SOkA) of the basin contain the preserved project documentation in all its phases. It consists of studies, technical reports and project documentation. For the project sites of interest, the SOkA Znojmo (EVL Vrbovecký rybník, EVL Hevlínské jezero, EVL Trávní dvůr), the SOkA Břeclav based in Mikulov (EVL Trkmanec-Rybníčky, EVL Trkmanské meadows, EVL Slanisko Dobré Pole, EVL Slanisko Novosedly) and the SOkA Hodonín (EVL Vypálenky and EVL Kosteliska) were relevant. The obtained documents have already been partially used and are still being processed, with the relevant situations of drainage structures being spatially located (orthorectified) and the most important drains vectorised.

Remote sensing (RS) methods were also used to confirm the physical existence of drainage structures in the landscape. The LPR methods allow the detection of hydraulic drainage, however, in most cases the entire structure is not identified, rather fragments of it, and the total extent of drainage on a particular piece of land is only identifiable by detailed local investigation including excavation. To identify the presence of drainage systems in the area, WMS services with historical orthophotos from the Czech Office of Surveying and Cadastre (ČUZK), the same type of WMS services from LPIS (from the eagri.cz portal), as well as map services from Google and Mapy.cz or archival aerial photographs (ALMS) provided by ČÚZK were used. These data are visualised in ArcGIS or in the online mapping environment of specific source sites and then analysed for the presence of drainage systems.

3.5. Sewerage and Wastewater Treatment Plants Analysis

The analysis of the potential for water pollution in the target SCIs from municipal wastewater was conducted based on data from the Water Supply and Sewerage Development Plan for the

South Moravian Region (PRVK JMK), provided by the South Moravian Regional Authority's Environmental Department. The data include point layers for "wastewater treatment plants," "discharge outlets," "pumping stations," and "retention basins," as well as the linear layer for "sewer lines."

3.6. WATER QUALITY ANALYSIS

3.6.1. Monitoring of Chemical Water Quality in the Pilot Sites

For water quality monitoring, profiles were first selected on the tributaries of the SCIs, namely the Vrbovecký Stream, Hrabětický Stream, and Bílovický Stream. Monitoring was conducted through six campaigns from December 2023 to July 2024 to cover both non-vegetation and vegetation seasons (particularly for pesticide application). Monitoring included basic chemical water parameters. A summary of the monitoring campaigns and the parameters tested is provided in Table 2.

Table 2: Overview of measurement profiles, monitoring campaigns and monitored characteristics. CH – basic chemical parameters (Conductivity, chemical oxygen demand (Cr), sulphates, chlorides, NO_3, NH_4, Norg, phosphates, Ptot., Corg). P – pesticides (screening of 284 substances). TK – heavy metals (Pb, Hg, Zn, As, Ni, Cu, Cr, Cd).

Site	Coordinates		Monitored parameters					
	x	y	VIII.23	XII.23	III.24	IV.24	VI.24	VII.24
Vrbovecký potok (stream)	-638133,33	-1201266,02	CH	CH, TK, P	CH	CH, P	CH, P	CH, TK, P
Vrbovecký rybník - tůň (pool)	-637776,47	-1201408,46	n	n	n	n	CH, P	CH, TK, P
Hevlínské jezero (lake)	-621677,74	-1206456,65	CH	CH, TK	CH	CH, P	CH, P	CH, TK, P
Trávní dvůr – Hrabětický potok (stream)	-615836,69	-1203694,71	CH	CH, TK	CH	CH, P	CH, P	CH, TK, P
Trávní dvůr – pod vúustí (under the outlet)	-615836,69	-1203694,71	n	n	CH	CH	CH	CH, TK
Travní dvůr – tůň Rýžoviště (pool)	-616017,05	-1204318,92	n	CH, TK	CH	CH	CH, P	CH, TK
Trkmanec – Bílovický potok (stream)	-584337,64	-1199208,00	CH	CH, TK	CH	CH, P	CH, P	CH, TK
Trkmanec velká tůň (big pool)	-584773,43	-1199174,29	n	CH, TK	CH	CH	CH, P	CH, TK, P
Trkmanec malá tůň (small pool)	-585187,79	-1199249,06	n	CH, TK	CH	CH	CH, P	CH, TK
Trkmanec střední stoka (middle ditch)	-585120,21	-1198643,35	CH	CH, TK	CH	CH	CH	CH, TK

Vypálenky tůň (pool)	-548887,06	-1190759,45	CH	CH, TK	CH	CH	CH, P	CH, TK
Vypálenky kontrola	-548913,64	-1189954,01	n	CH, TK	CH	CH	CH	n
Husí pastviště	-601632,32	-1191991,44	n	CH, TK	CH	CH	CH	CH, TK
Kosteliska	-567588,88	-1193238,24	n	CH, TK	CH	CH	CH	CH, TK
Novosedly	-610493,49	-1199198,95	n	CH, TK	CH	CH	CH	n
Novosedly revitalizace	-610474,92	-1199092,50	n	n	n	n	CH	n
Dobré Pole	-608113,04	-1201438,53	n	CH, TK	CH	CH	CH	CH, TK, P

3.6.2. Laboratory Analyses

For laboratory analyses, typical pollutants found in Czech surface waters were selected, including pesticides and their metabolites, along with a screening of selected heavy metals. Water samples were tested for concentrations of nitrates (NO_3^-), ammonium ions (NH_4^+), organic nitrogen (Norg), dissolved phosphates (PO_4), total phosphorus (Ptotal), and dissolved organic carbon (Corg. DOC). Water salinity was assessed by measuring concentrations of sulfates and chlorides. Additionally, each sample was tested for electrical conductivity, dissolved oxygen content, and chemical oxygen demand using the dichromate method (COD_Cr). Heavy metals analyzed included lead, copper, mercury, arsenic, cadmium, chromium, zinc, and copper. Samples were collected manually, and analyses were conducted by the accredited laboratory of the Research Institute for Soil and Water Conservation (VÚMOP, v.v.i.) using an ICP-OES (Inductively Coupled Plasma Optical Emission Spectrometer) and a mercury analyzer AMA–254.

To assess the risk of water contamination by pesticides and their metabolites, monitoring profiles were established in pilot SCIs identified as potentially vulnerable due to a high share of agricultural land and, in particular, drained agricultural land in their catchments. These include the SCI Vrbovecký rybník and its tributary Vrbovecký potok, the SCI Trávní dvůr and its main tributary Hrabětický potok, and the SCI Trkmanec – Rybníčky with its main tributary Bílovický potok. Four monitoring campaigns were carried out at these locations (December 2023, April 2024, June 2024, and July 2024), aiming to cover both the pesticide application and non-application seasons, especially on the selected tributaries. At other monitored sites, a screening for pesticide concentrations was conducted during the application season.

The water samples were analyzed for pesticide concentrations by certified ALS laboratories (https://www.alsglobal.cz/). The list of pesticides analyzed was based on prior research on the leaching of pesticide substances from agricultural soils (Richards et al., 2001; Zajíček et al., 2018). In total, the presence of 284 pesticides and their metabolites was tested. For the analysis of pesticides in drainage and surface waters, five analytical methods were applied: W-PESLMS02, W-PESLMS04, W-PESLMNS07, W-PESLMSD1, and W-PESLMS10. Sample preparation for laboratory testing was based on the principle of direct sample injection, with the exception of the method for glyphosate and AMPA (which requires a derivatization step) and the method for 1,2,4-triazole, which includes solid-phase extraction (SPE). Information on the properties of the tested pesticides and their metabolites was obtained from the Pesticide Properties Database (herts.ac.uk).

3.7. PROPOSED MEASURES

Measures aimed at improving water quality and the hydrological regime of the selected sites were proposed based on the results of water quality analysis, natural condition assessments, and identification of pollution sources. During the design process, land ownership and property rights on the parcels affected by the proposed measures were also considered, to ensure realistic implementation either within this project or in follow-up activities.

The proposed measures were primarily organizational in nature, focusing on changes in land use (e.g., conversion to pasture, establishment of permanent grasslands, or grassing of arable land), revitalization of watercourses within the target sites, and small-scale biotechnical solutions such as constructed wetlands, root-zone treatment systems, or biofilters, all designed to reduce pollution in water entering the sites.

The design of these biotechnical measures was based on approaches described in the Catalogue of Measures developed by a consortium for the state enterprise Povodí Vltavy under the River Basin Management Plan (PVL). Additional types of measures were derived from the global WOCAT (World Overview of Conservation Approaches and Technologies) database.

Measures were selected for locations where water quality was demonstrably at risk due to both point and diffuse pollution sources and where local interventions had realistic potential to improve water quality and hydrological conditions. Conversely, in two locations – SCI Husí pastviště and the Kosteliska site – no measures were proposed, as their water quality is significantly influenced by large water bodies and minor biotechnical interventions would not yield the desired effect. Similarly, no measures were suggested for the Trkmanské louky site, where no relevant water features were detected.

4. RESULTS

4.1. SAC VRBOVECKÝ RYBNÍK

The Vrbovecký rybník site (Fig. 2) is part of the NATURA 2000 network under the code CZ0623030 and covers an area of 37.1 hectares. Its protection status falls under national nature conservation as a Natural Monument (PP). This site is of particular importance for the protection of the fire-bellied toad (Bombina bombina) and the vegetation of exposed pond bottoms (habitat 3130 – oligotrophic to mesotrophic stagnant waters).

Figure 2: View of SAC Vrbovecký rybník (July 2024)

4.1.1 Site Description and Contributing Catchment

The catchment area contributing to the SAC Vrbovecký rybník encompasses 2 498,1 hectares. From a geological perspective (Fig. 3), the catchment area is composed of Quaternary sediments of the Bohemian Massif unit – cover formations and post-Variscan magmatites. The upper catchment features loess and loess loams, while the lower catchment consists of unconsolidated sands to gravels (mostly clayey and sandy in grain size). Alluvial sediments (clay, sand, gravel) with depths of 5–10 meters occur along the Vrbovecký potok stream and within the SCI area itself.

Geomorphologically, most of the area belongs to the Jaroslavice Upland, a subunit of the Dyje-Svratka Valley, characterized as a flat lowland hilly landscape formed by Neogene and Quaternary deposits. The highest part of the catchment lies within the Znojmo Upland, a subunit of the Jevišovice Upland, which forms part of the Bohemian-Moravian Highlands. The prevailing soil types (Fig. 4) are Chernozems, with Gleyic soils (Gleysols) forming near the stream and within the SCI site. Most of the soils belong to Hydrological Group B, indicating moderate infiltration capacity; however, soils within and near the SCI site are classified as Group D, with very low infiltration rates.

The area is drained by the Vrbovecký potok stream (CEVT ID: 10188556), which is 4 550 meters long and originates at the northwestern edge of the village Vrbovec. It follows a partially piped watercourse that begins near the village of Popice by Znojmo. Vrbovecký potok is a right-bank tributary of the Daníž River, flowing into it 3.5 km downstream from the village, west of it, and is also the sole tributary to the Vrbovecký rybník pond.

The catchment is intensively used for agriculture (Fig. 5). According to data from the LPIS (Land Parcel Identification System), agricultural land covers a significant 79,2% of the catchment area, with arable land dominating at 61,2%. According to the ZVHS database, agricultural drainage infrastructure is documented on 85,5 hectares, with part of the drainage confirmed via remote sensing (DPZ).

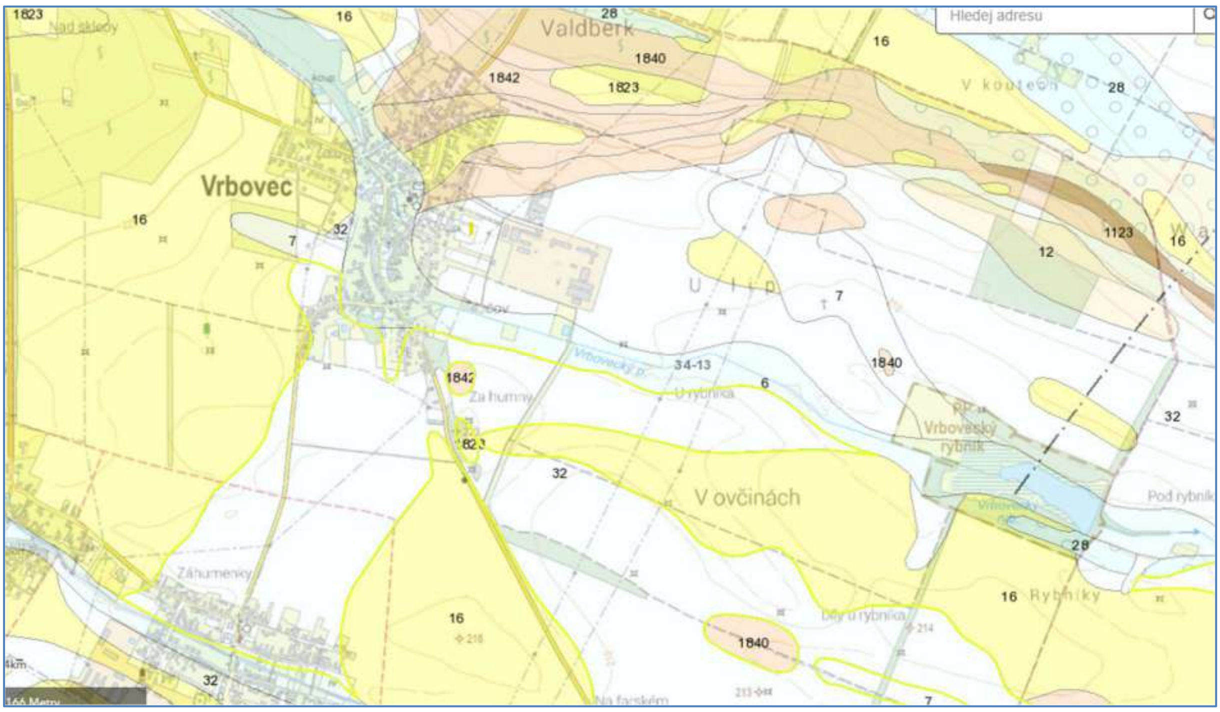

Figure 3: Geological background of the SAC area Vrbovecký rybník (ČGS database), 6 – alluvial sediment (clay, sand, gravel), 7 – mixed, mostly fine-grained sediment, 16 – eolian unconsolidated sediment (loess and loess clay), 32 – fluviolacustrine unconsolidated sediment (sand, gravel), 1840–1842 – marin unconsolidated sediment (calcareous clay)

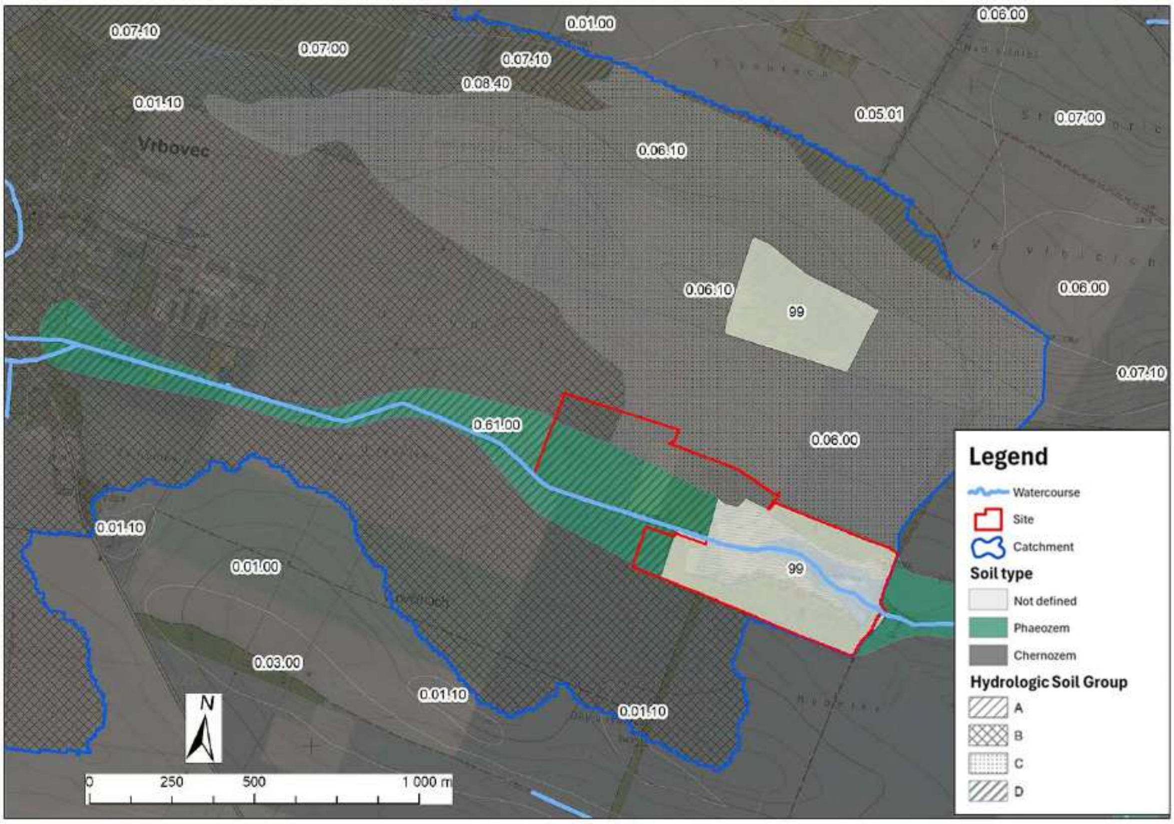

Figure 4: Soil cover in the locality of SAC Vrbovecký rybník

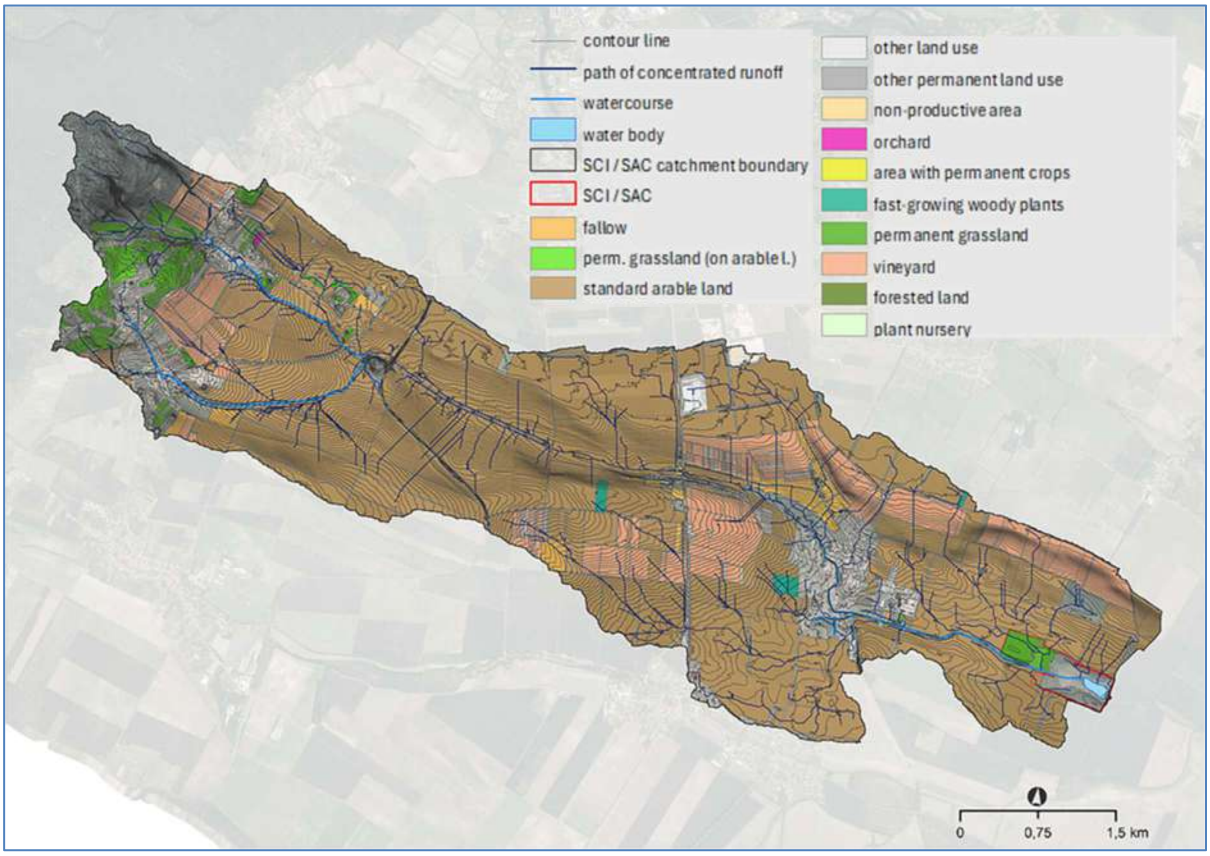

Figure 5: Land use in the catchment of SAC Vrbovecký rybník

4.1.2. Main Ecological Challenges

The main ecological challenges for the Vrbovecký rybník site involve alterations in the water regime and water pollution, which threaten key habitats and target species populations. Long-term eutrophication and sedimentation of the pond lead to habitat and vegetation degradation, negatively impacting the breeding success of the fire-bellied toad (Bombina bombina). Another pressing issue is the spread of expansive and invasive species, which outcompete native vegetation and disrupt ecological balance.

4.1.3. Analysis of Water Pollution Sources

Water inflow into the SCI and the resultant water quality are largely determined by the Vrbovecký potok stream. The water quality of the stream is primarily affected by municipal pollution, with its source being the discharge point of the Vrbovec wastewater treatment plant (WWTP). The village of Vrbovec (population: 1 232) is mostly equipped with a combined sewer system, with a separate system in the southern part. According to VUME (2022), 1 042 inhabitants are connected to the sewerage network. Several storm overflow chambers are installed in the combined sewer system, which discharge diluted wastewater into the recipient during periods of increased precipitation, ensuring the required dilution ratio. These chambers are essential for managing hydraulic capacity and preventing excessive dilution of wastewater that could impair biological processes at the WWTP.

The Vrbovec WWTP is a mechanical-biological treatment plant featuring nitrification and denitrification, nitrogen removal, aerobic sludge stabilization, and gravity sludge dewatering. The plant was constructed in 2003 and commissioned for permanent operation in 2004. It includes mechanical pretreatment facilities (inlet pumping station, coarse manual screens, fine mechanical screens, sand trap, sand separator, holding tank for transported septage), biological treatment units (aeration tank, secondary clarifier, blower, aeration system), and sludge management facilities (aeration system, storage tank, sludge pump). The plant also includes a stormwater holding tank. Recently, the aeration system was replaced, and technological equipment was upgraded. The WWTP has a design capacity of 1 300 population equivalents (PE). It contributes an annual load of 84 kg $N–NH_4^+$ and 262 kg total phosphorus (P_{tot}).

The water quality in the catchment is also affected by extensive areas of intensively farmed arable land, where row crops such as maize and sunflower are commonly cultivated. Agricultural practices are a source of diffuse pollution, particularly due to nitrate leaching, pesticide and metabolite runoff, and potential phosphorus enrichment.

These pollution sources are graphically depicted on the map in **Figure 6**.

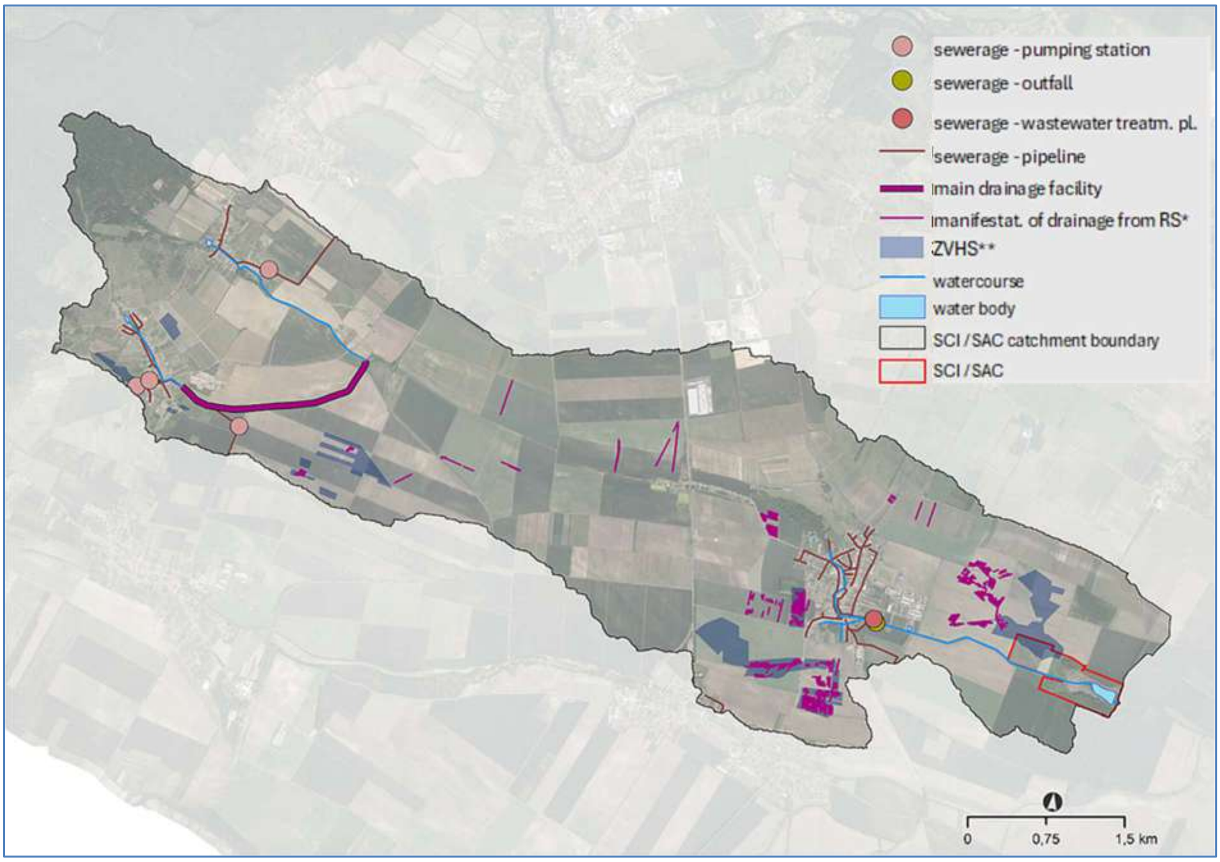

Figure 6: Sources of water pollution in the catchment of SAC Vrbovecký rybník;
**RS – Remote Sensing; **Former Agricultural Water Management Administration (in Czech ZVHS)*

4.1.4. Water Quality in the Vrbovecký rybník SCI

Two monitoring profiles were established in this area: the Vrbovecký potok stream, representing the main inflow into the SCI above the pond, and the Vrbovecká tůň pool, located in a waterlogged section further downstream. The results of water quality analysis are presented in Table 3 (basic chemical indicators) and Table 4 (pesticide compounds).

Vrbovecký stream

In terms of stream water composition, relatively high concentrations of sulfates were measured in the Vrbovecký potok (average 229 mg/L), while chloride levels were lower (133 mg/L). Nitrogenous compounds included very low concentrations of nitrates (average 5.2 mg/L) and organic nitrogen (average 1.8 mg/L), but elevated concentrations of ammonium ions (ranging from 0.1 to 1.5 mg/L), particularly during the summer low-flow period, when most of the streamflow likely originated from the WWTP discharge. The average concentration of ammonium nitrogen was 0.68 mg/L, corresponding to Class III water quality under ČSN 75 7221. The stream is heavily burdened with phosphorus, both in the form of dissolved orthophosphates (average 4.8 mg/L) and total phosphorus (5.4 mg/L), with the latter corresponding to Class V water quality. Elevated values were typical especially during low-flow summer periods. These high phosphorus levels, indicative of fecal contamination, significantly contribute to eutrophication in the Vrbovecký pond. Strong organic pollution is further evidenced by high chemical oxygen demand (CODCr), with an average value of 50 mg O_2/L (Class IV water quality), while concentrations of total organic carbon (TOC) were relatively lower (average 9.72 mg/L), again suggesting predominantly municipal pollution.

Regarding heavy metals, no significant concentrations were detected in the Vrbovecký potok.

High pesticide concentrations (3.4–10.9 µg/L) were detected in the stream, particularly during the application season (Figure 7). A total of 26 pesticide compounds were identified, although most were present in relatively low concentrations (tens of ng/L). Glyphosate and its metabolite AMPA dominated the sum concentration, accounting for 89–96% of the total pesticide load (glyphosate: 0.4–4.9 µg/L; AMPA: 2.7–5.3 µg/L). These exceptionally high concentrations are unlikely to originate solely from agricultural activity. A probable source is the local wastewater treatment plant, where glyphosate is used extensively for weed control in urban areas, but where no technology is in place to remove such compounds.

A compound of verified agricultural origin, the common metabolite of azole fungicides, 1,2,4-triazole, was detected in all samples with an average concentration of 0.21 µg/L. The herbicide MCPA was found in a June sample at a concentration of 0.31 µg/L. Despite the stream flowing through an area of intensive agriculture, with parts of the land systematically drained, concentrations of other pesticide compounds remained very low—typically in the range of single or tens of nanograms per liter.

Vrbovecký rybník – Pool

Monitoring was carried out at one of the pools constructed in 2023. This profile showed significant water contamination, particularly in terms of conductivity (average 1,118 µS/cm), CODCr (average 57.9 mg O_2/L), and TOC (average 19.2 mg/L). Phosphorus concentrations were lower, with total phosphorus levels corresponding to Class II water quality. The pool was characterized by very low concentrations of ammonium nitrogen (Class I water quality) and comparatively higher (yet still low in absolute terms) nitrate levels (20.1 mg/L), as compared to the stream.

Elevated concentrations of arsenic (20.5 µg/L, corresponding to Class IV water quality) and nickel (33.3 µg/L, Class III) were detected in summer sampling.

Two monitoring campaigns for pesticide concentrations were conducted in this locality. Surprisingly high pesticide concentrations were found in both campaigns (11.1 and 7.5 µg/L, respectively), including parent compounds. In the June sampling, conducted during the peak application season, parent compounds accounted for approximately 50% of the total concentration (5.4 µg/L). Notably high concentrations were measured for nicosulfuron (average 1.5 µg/L), metolachlor (0.8 µg/L), and terbuthylazine (0.6 µg/L). These elevated levels indicate a significant risk of agricultural contamination to the waters of the Vrbovecký rybník SCI.

Table 3: Average values of monitored water chemical indicators at SAC Vrbovecký rybník

Parameter / profile	CON (mS/m)	$CHSK_{Cr}$ (mg/l)	Corg (mg/l)	Chlorides (mg/l)	Sulphates (mg/l)	$N\text{-}NH_4^+$ (mg/l)	$N\text{-}NO_3^-$ (mg/l)	N org. (mg/l)	$P_{tot.}$ (mg/l)	PO_4 (mg/l)
Vrbovecká Pool	112	57,85	19,15	114	297	0,18	4,54	2,18	0,28	0,12
Vrbovecký stream	110	50,36	9,72	133	229	0,68	1,17	1,76	5,35	4,76

(Classification according to Surface water quality classification: ČSN 75 7221–Klasifikace kvality povrchových vod. Úřad pro technickou normalizaci, metrologii a státní zkušebnictví, 2017)

I	Unpolluted water
II	Slightly polluted water
III	Polluted water
IV	Heavily polluted water
V	Severely polluted water

Table 4: Results of pesticide substances monitoring at SAC Vrbovecký rybník

Profile	samples (n)	Detected compounds (n)	Total concentration (µg/l)	Pesticide parent compound with the highest concentration (µg/l)	Metabolite of the pesticide with the highest concentration (µg/l)
Vrbovecký stream	4	26	3,4 - 10,9	glyphosate (2,7)	AMPA (4,4)
Pool	2	13	7,5 - 11,1	nicosulfuron (1,5)	metolachlor OA (2,0)

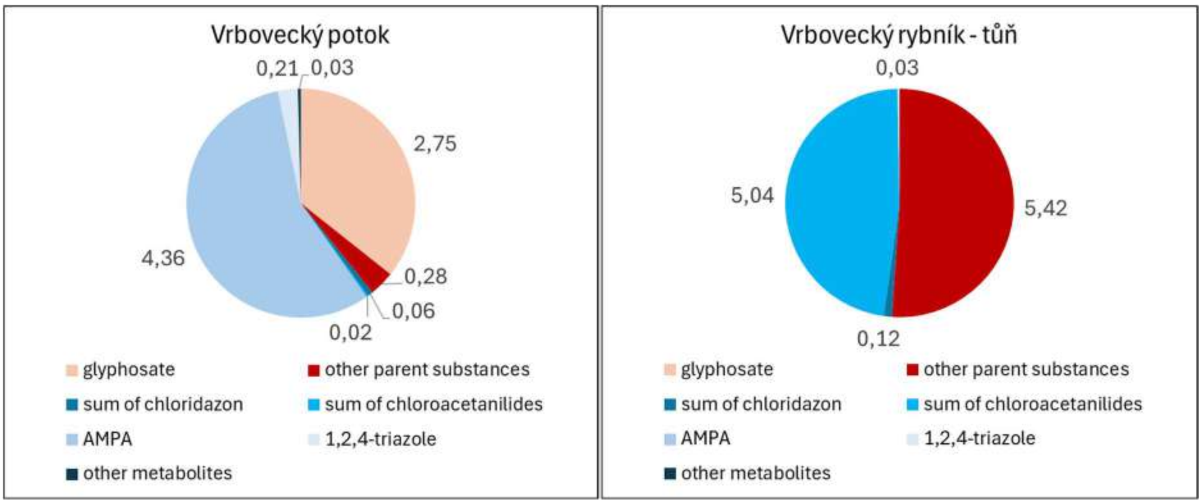

Figure 7: Composition of pesticide substances in waters of SAC Vrbovecký rybník

Summary of Water Quality Monitoring Results

The monitoring results indicate that water in the Vrbovecký rybník SAC is primarily affected by municipal pollution originating from the nearby village of Vrbovec. This includes elevated concentrations of ammonium ions, phosphorus, and chemical oxygen demand (COD). High concentrations of glyphosate and its metabolite AMPA were also detected, most likely resulting from herbicide application within the built-up areas of the village.

The monitored pool is influenced by agricultural activity but also shows high concentrations of organic substances, likely derived from decomposing biomass. Specific pollutants include nitrates, organic pollution, and—surprisingly—elevated concentrations of pesticides (11.1 and 7.5 μg/L, respectively), clearly attributable to agricultural practices. In summer sampling, relatively high concentrations of arsenic and nickel were also detected in the pool.

4.1.5. Measures to Stabilize the Water Regime and Improve Water Quality

To improve water quality in the Vrbovecký rybník SAC, a comprehensive set of measures should be implemented in the lower catchment of the Vrbovecký potok stream. An overview of the proposed measures is provided in Figure 8.

To reduce municipal pollution input, a separate sewerage system for the entire village of Vrbovec should be constructed (measure VRB 1), along with an upgrade to the sludge management system of the local wastewater treatment plant (measure VRB 2). Implementation of these measures should be the responsibility of the municipality, with support from public funding programs of the EU and the Czech Republic. These interventions have significant potential to reduce municipal pollution entering the Vrbovecký potok stream and subsequently the protected SCI area.

Measures aimed at directly removing pollution from the Vrbovecký potok include two systems based on constructed wetlands/biofilters. These systems comprise several interconnected components functioning as a whole.

The first constructed wetland system (measure VRB 3) is located upstream along the Vrbovecký potok on parcel no. 8529 in the cadastral area of Vrbovec. This land is privately owned and currently used as arable land. The system includes localized channel excavation (3a) along approximately 170 meters of the stream. At the upper end of this section, a diversion structure (3b) will be installed—a manhole allowing water to be withdrawn from the stream (or slightly impounded if necessary due to terrain slope) and directed via an underground pipe (3c) into the constructed wetland (3d). The wetland itself consists of a shallow basin (lined with impermeable foil as needed), filled with a root-zone filter made of fine gravel and organic material colonized by bacteria that facilitate water purification. Planted vegetation plays a supporting role—absorbing nutrients, supplying oxygen, hosting microbial life on the roots, and acting as thermal insulation in winter. The filter substrate will consist of wood chips mixed with biochar (alternatively peat or vermiculite). The final design and dimensions will be refined based on detailed field survey and terrain measurements to ensure sufficient retention time. Treated water will be returned to the stream through a discharge pipe (3e) and outlet structure

(3f). The system aims to improve water quality, prevent unwanted waterlogging of the parcel, and maintain sufficient base flow in the stream. The wetland system will be accompanied by grassed buffer zones (3g) covering 6,650 m² to allow for access and maintenance. A schematic of this system is shown in Figure 9.

The second wetland system (measure VRB 4) will be situated in the lower part of the Vrbovecký potok stream on parcel no. 8565 in the Vrbovec cadastral area. This parcel, currently permanent grassland, is state-owned and managed by the Nature Conservation Agency of the Czech Republic. Like the previous system, it consists of multiple functional components: streambed excavation along 300 meters (4a), enabling water inflow to the wetland; a diversion structure (4b) that directs a constant portion of the streamflow to the wetland; and, if needed, slight water impoundment to provide a sufficient gradient. Withdrawn water will flow through an underground pipe (4c) to a forebay pond (4d) that accumulates water during high flows and ensures steady inflow into the wetland for appropriate retention time. From the forebay, water will be conveyed to the constructed wetland (4e), which will be similar in design to the previous system. Treated water will then be discharged through a pipe (4f) and outlet (4g) back into the excavated streambed. Alternatively, infiltration into a surrounding wetland area may be considered. The schematic layout is presented in Figure 10.

A system of grassed buffer strips (measure VRB 5) is proposed along the right bank of the Vrbovecký potok to protect wetland areas from the influx of pollutants from adjacent agricultural land, whether via surface runoff or subsurface flow. Three grassed zones have been proposed. Parcel no. 8547 (5a), state-owned and currently used as arable land, lies within the protection zone of the SCI and is separated from adjacent land by a field road. Additional areas suitable for grassing include portions of parcels no. 8460 (5b) and 8457 (5c), which are owned by an agricultural enterprise. Extensive grazing is proposed as a suitable protective management approach. A schematic of this system is presented in Figure 11.

Another highly recommended measure is the revitalization of the stream segment from the wastewater treatment plant outlet to the confluence with the Vrbovecký rybník (VRB 6). Ideally, this would involve comprehensive channel restoration, including excavation, modification of stream alignment and gradient, channel cleaning, and establishment of appropriate riparian vegetation. However, the feasibility of this measure is currently limited, mainly due to the recently completed Land Consolidation Project, which has left insufficient available land along the stream for implementation.

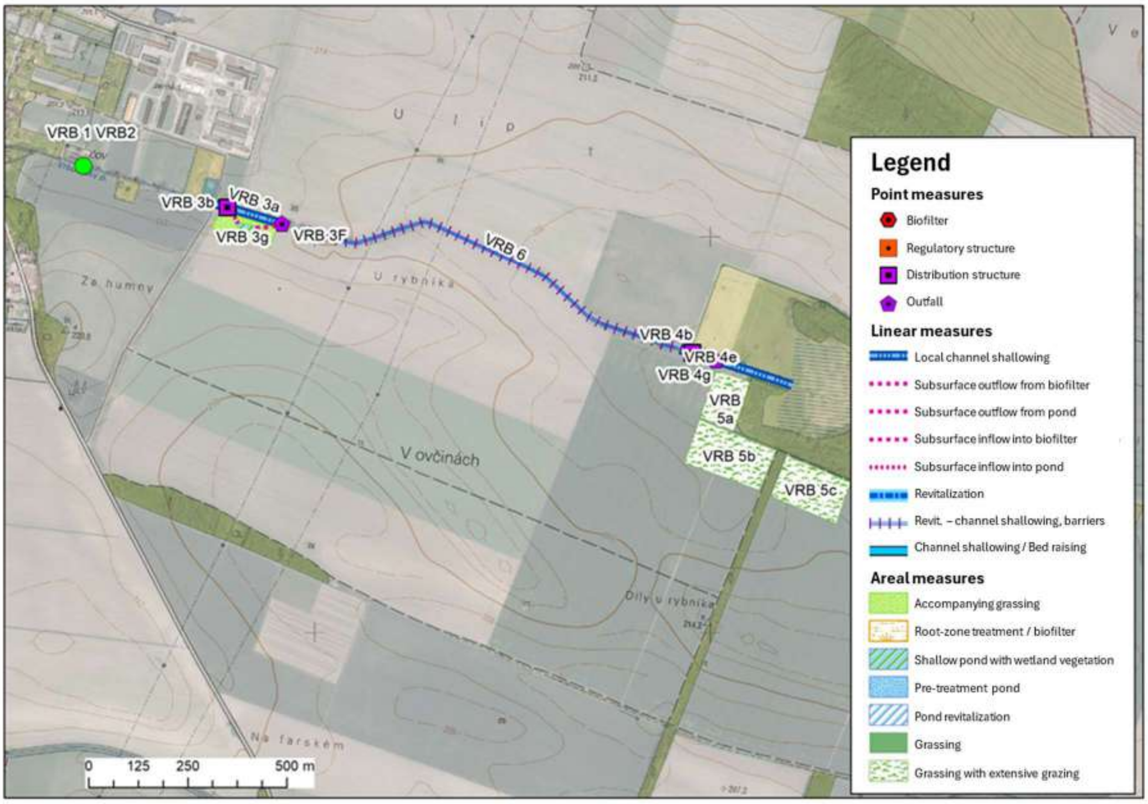

Figure 8: Overview of measures proposed in the SAC Vrbovecký rybník catchment

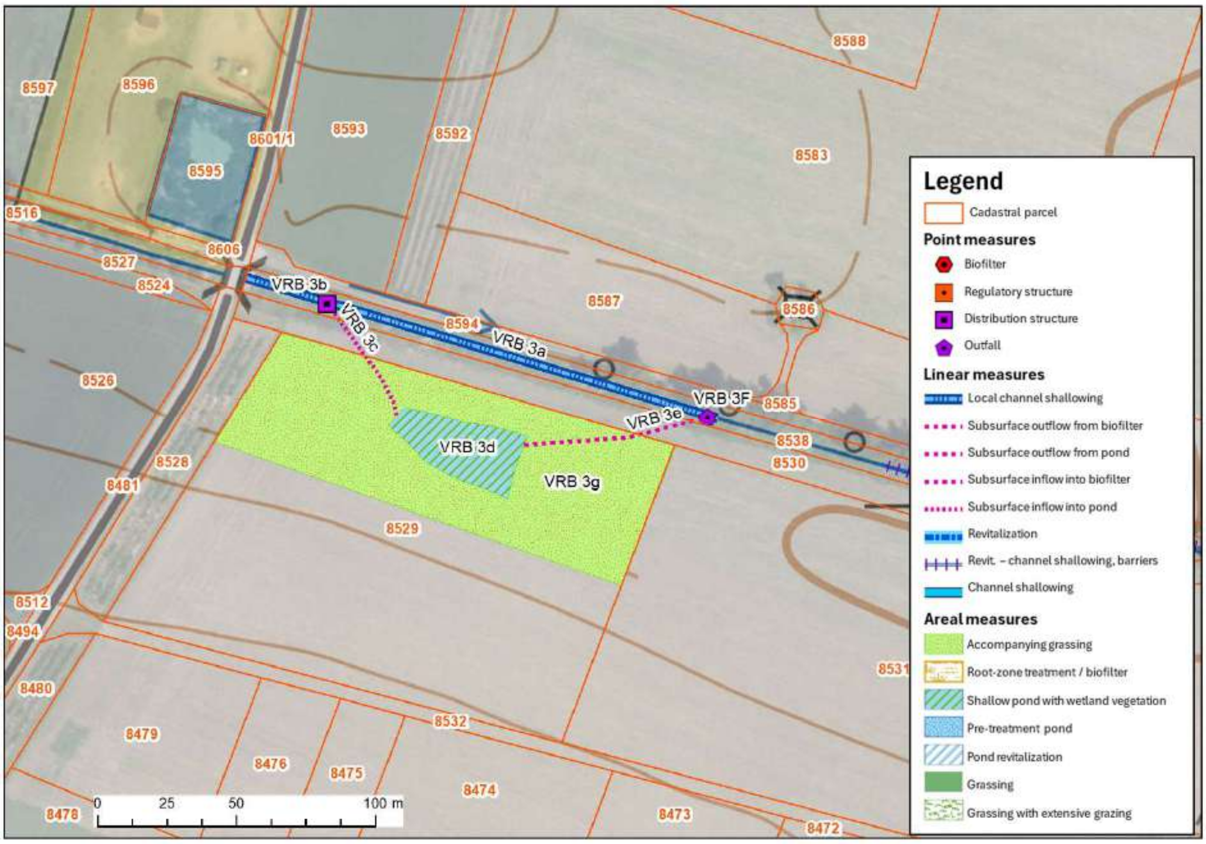

Figure 9: Root treatment system designed in the SAC Vrbovecký rybník catchment

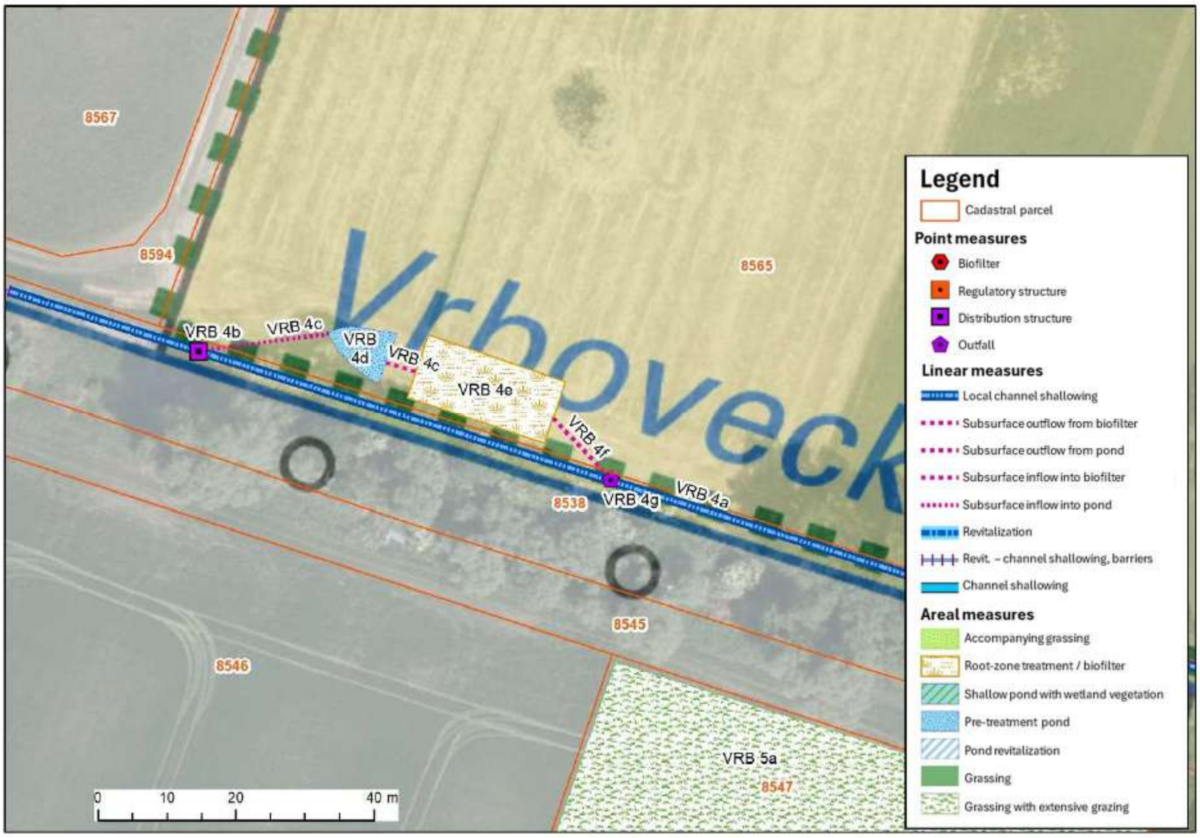

Figure 10: Biofilter/root treatment system designed in the SAC Vrbovecký rybník catchment

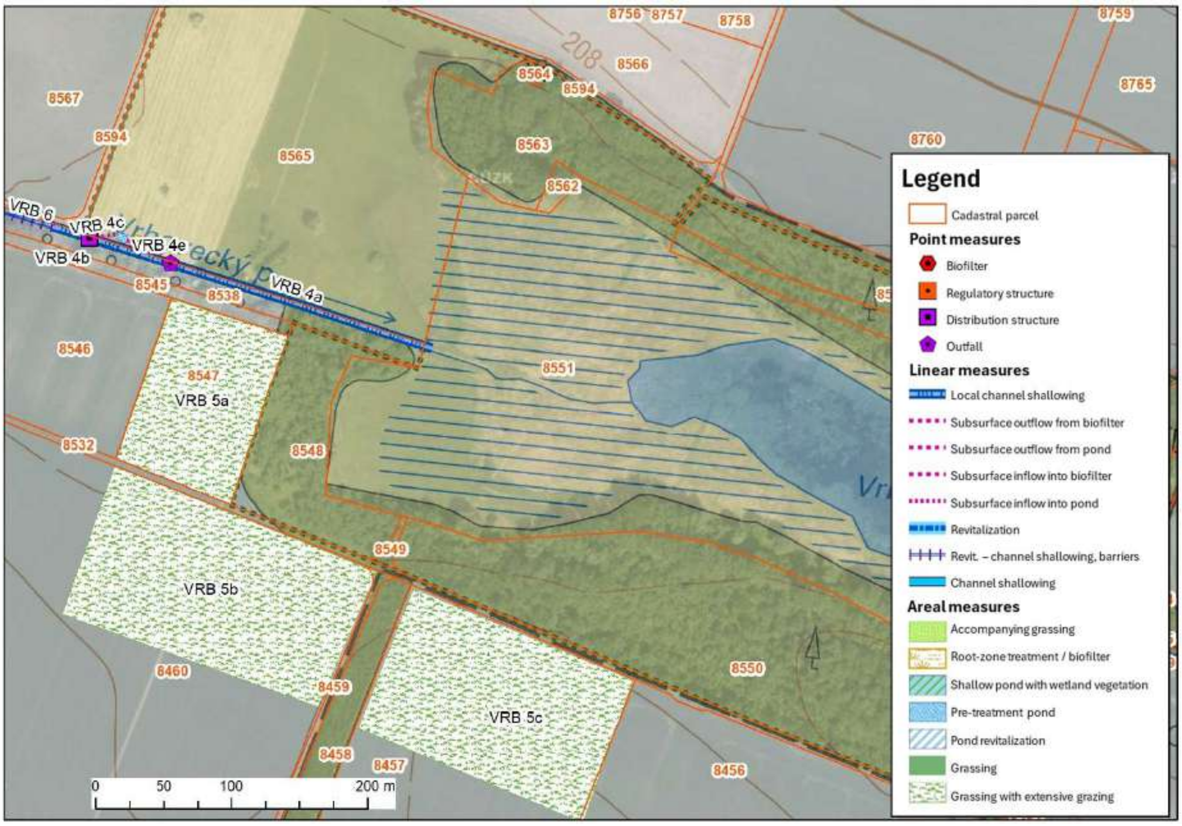

Figure 11: Conversion of arable land to permanent grassland with extensive grazing in the SAC Vrbovecký rybník catchment

4.2. SAC Hevlínské jezero

Hevlín Lake (Fig. 12) is a Special Area of Conservation (SAC) included in the NATURA 2000 network under code CZ0623010, covering an area of 9.4 ha. It is located in the Pannonian biogeographical region, in the South Moravian Region, Znojmo District. The site falls under national protection as a Natural Monument (PP). The primary conservation focus is on aquatic and wetland habitats and the presence of endangered amphibian species, particularly the fire-bellied toad (Bombina bombina).

Figure 12: View of SAC Hevlínské jezero (June 2024)

4.2.1. Site Description and Contributing Catchment

The site consists of a permanently waterlogged terrain depression, fed by groundwater and precipitation. Hevlín Lake is an important wetland habitat featuring a mosaic of reedbeds and open water surfaces, which are, however, gradually degrading due to eutrophication and sedimentation. The hydrological catchment of SAC Hevlín Lake covers an area of 25.1 ha. From a geological perspective (Fig. 13), the site is formed by unconsolidated layered sediments (mainly calcareous clays and calcareous sands and gravels) of the Carpathian Foredeep (Cenozoic era). In the northern part of the catchment, fluvial sediments of the Bohemian

Massif—cover layers and post-Variscan migmatites—are also present, consisting mainly of unconsolidated gravels and sands.

Geomorphologically, the catchment belongs to the Drnholec Upland subunit, part of the Dyje-Svratka Valley unit, within the Western Outer Carpathian Depressions subprovince of the Outer Carpathian Depressions province.

The soil cover (Fig. 14) outside the waterlogged area predominantly comprises Chernozem (BPEJ 0.04.01 and 0.05.01 – Chernozems primarily on flat or completely flat terrains with all-direction exposure and skeletal content below 25%). The soils are deep to moderately deep, located in a very warm, dry climatic region, and are of low productivity. A belt of forest soil occurs at the northern edge of the wetland. The SAC and its surroundings fall into Hydrological Soil Group A, characterized by high infiltration rates and low water retention capacity.

The main watercourse near SAC Hevlín Lake is the Krhovice–Hevlín irrigation canal (IDVT 10441660, managed by Závlahy Dyjákovice, s.r.o.), specifically its feeder channel, N1. It is an artificial watercourse with a designed discharge of up to 5.3 m^3/s. The canal runs along the northwestern boundary of the catchment and is separated from the SCI by a reinforced embankment. However, irrigation detail from the canal supplies water north of the lake, and excess water may enter the lake during the irrigation season through an engineered outlet located in the northern part of the lake. The lake itself is drained by an unnamed stream (IDVT 10201550), 791 m in length, managed by the Morava River Basin Authority (Povodí Moravy, s.p.), though the land beneath the stream is designated as forest land under the management of Lesy České republiky (Czech State Forests).

The LPIS database indicates that 50.9% of the catchment consists of agricultural land, all of which is used as arable land and is located in the upper part of the catchment outside the SAC. According to the ZVHS database, there are no registered agricultural drainage systems in the catchment, despite the broader area having been subject to intensive drainage (Fig. 16), and the presence of active irrigation systems. Remote sensing analysis (DPZ) also failed to identify any drainage systems within the SCI catchment. Historically, there were several projects aimed at converting the lake into a fishpond or completely drying it out; however, none of these plans were realized.

Within the catchment of SAC Hevlín Lake, two concentrated runoff pathways were identified (Fig. 15), which flow southeast across the catchment area toward the NW boundary of the SAC and may represent potential sources of pollution during significant rainfall-runoff events. There is no sewer infrastructure or wastewater treatment plant within the catchment, thus eliminating the possibility of municipal pollution. Potential sources of diffuse pollution include surrounding arable land and possibly contaminated groundwater feeding the lake.

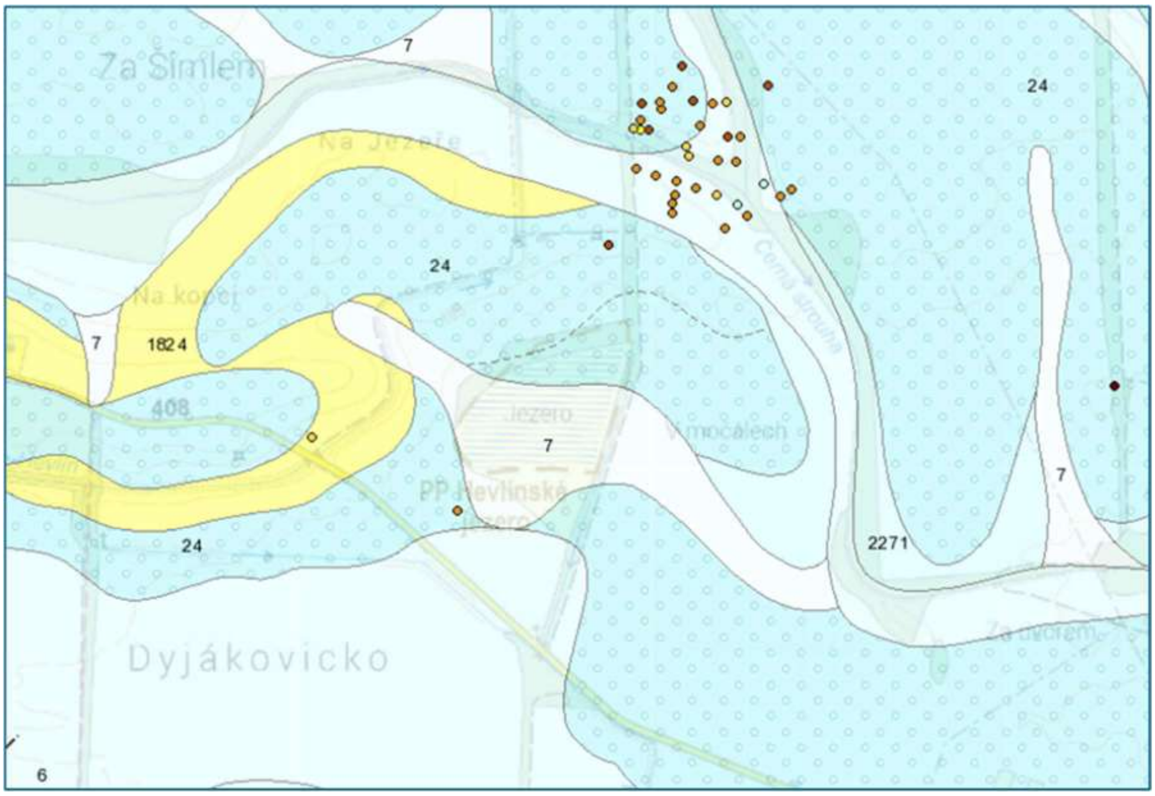

Figure 13: Geological background of the SAC area Hevlínské jezero (ČGS database); 6 - fluvial unconsolidated alluvial sediment, 7 - mixed sediment (mostly fine-grained), 24 - fluvial unconsolidated sediment (sand, gravel), 1824 - marin unconsolidated sediment (calcareous clay), 2271 - mixed unconsolidated sediment (sandy humic clay)

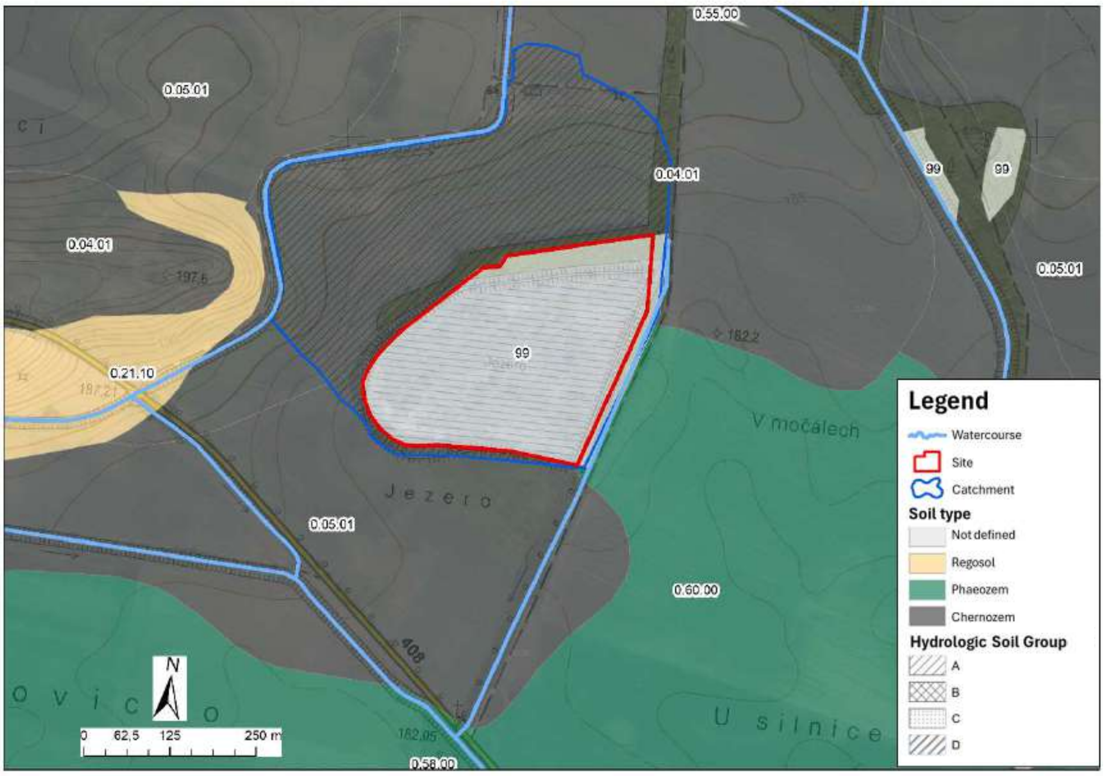

Figure 14: Soil cover in the SAC site Hevlínské jezero

4.2.2 Main Ecological Challenges

Key challenges include the infilling of water surfaces and gradual encroachment by reed and woody vegetation, which reduces the suitability of the site for the reproduction of fire-bellied toads and the occurrence and spread of less competitive (sub)halophytic species. Eutrophication, driven by nutrient runoff from adjacent agricultural land, also threatens the site's biodiversity. The absence of active management has led to wetland habitat degradation, which now necessitates intervention to restore open water and marsh areas.

4.2.3 Pollution Source Analysis

The water quality of the SAC is only minimally threatened by point or diffuse pollution sources. The Krhovice–Hevlín main irrigation canal runs along the northwest edge of the SCI catchment but is topographically separated from the site by a terrain incision. No agricultural drainage systems were identified in the SAC area. However, the arable land in the northern part of the catchment is intensively irrigated. Water infiltrating from this irrigation into the lake could pose a potential risk to water quality, as could surface runoff during extreme rainfall-runoff episodes—particularly along two concentrated runoff paths (Fig. 15), which flow southeast across the catchment into the NW corner of the SAC. No sewer systems or wastewater treatment plants are present in the catchment, thus excluding municipal pollution as a risk factor for lake water quality.

Figure 15: Land use in the catchment area of the SAC Hevlínské jezero

Figure 16: Sources of water pollution in the catchment area of the SAC Hevlínské jezero
**RS – Remote Sensing*

4.2.4 Water Quality in the Hevlínské jezero SAC

Water samples from Hevlínské jezero were collected directly within the lake. A summary of the results is presented in Table 5. In terms of salinity, very low concentrations of sulfates and chlorides were detected at this site, averaging 139 mg/l and 80 mg/l, respectively. Similarly, nitrogen compounds were present at low levels. Nitrate concentrations averaged 2.5 mg/l (i.e. 0.56 mg/l as nitrate nitrogen), and ammonium ion concentrations averaged 0.28 mg/l (i.e. 0.22 mg/l as ammoniacal nitrogen), corresponding to water quality class I and II under Czech standard ČSN 75 7221, suggesting minimal agricultural or municipal pollution. Conversely, total phosphorus concentrations reached an average of 0.79 mg/l, which corresponds to water quality class V. The phosphorus load may originate from agricultural surface runoff or potentially from the irrigation canal Krhovice–Hevlín. The average concentration of organic carbon (Corg) was 17.3 mg/l, falling into class IV. Conductivity values during the sampling periods corresponded to class III and IV. The chemical oxygen demand (COD-Cr) was 77.5 mg/l, also falling into class V. High concentrations of organic carbon and COD-Cr indicate significant levels of decaying biomass in the lake water.

Concentrations of heavy metals in the lake water were very low, with most parameters falling within class I, except for arsenic during summer sampling (8.7 µg/l), which classified the water as class II.

As for pesticide concentrations (Fig. 17), the results confirm that despite its location in an intensively farmed region, the lake is largely hydrologically isolated from the surrounding agricultural landscape. This is reflected in the relatively low cumulative pesticide concentrations in the lake water, which ranged between 1.5 and 1.9 µg/l during the monitoring campaigns. These concentrations were dominated by metabolites (88–100 %), particularly chloridazon metabolites in the form of desphenyl and methyl-desphenyl derivatives. Additional substances detected included metabolites of chloroacetanilide herbicides, glyphosate metabolite AMPA, and the common metabolite of azole fungicides – 1,2,4-triazole. Parent compounds were found only in trace amounts, in the range of a few to several tens of nanograms.

Table 5: Average values of monitored chemical indicators in the Hevlínské jezero SAC

Parameter / profile	CON (mS/m)	$CHSK_{Cr}$ (mg/l)	Corg (mg/l)	Chlorides (mg/l)	Sulphates (mg/l)	$N\text{-}NH_4^+$ (mg/l)	$N\text{-}NO_3^-$ (mg/l)	Norg. (mg/l)	$P_{tot.}$ (mg/l)	PO_4 (mg/l)
Hevlínské jezero	87	77,50	17,28	80	139	0,22	0,56	2,76	0,79	0,66

(Classification according to Surface water quality classification: ČSN 75 7221–Klasifikace kvality povrchových vod. Úřad pro technickou normalizaci, metrologii a státní zkušebnictví, 2017)

I	Unpolluted water
II	Slightly polluted water
III	Polluted water
IV	Heavily polluted water
V	Severely polluted water

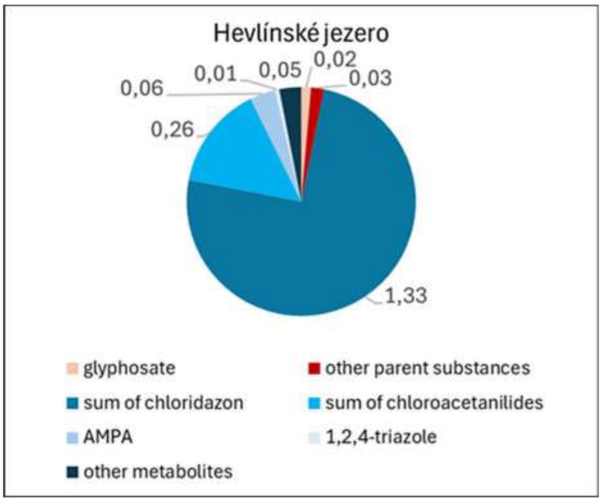

Figure 17: Composition of concentrations of pesticides and their metabolites in the waters of Hevlínské jezero (lake)

Summary of Water Quality Monitoring Results

The waters of Hevlínské jezero are currently affected primarily by organic matter, particularly organic carbon, with elevated COD-Cr values indicating a high content of decaying biomass. The presence of herbicide metabolites, especially chloridazon, suggests a degree of agricultural non-point source pollution. However, nitrate concentrations, which serve as a key indicator of agricultural pollution, were very low. A potential source of non-point pollution could be the intensively irrigated arable land in the northern part of the catchment area, where pollutants could be transported via percolation (subsurface flow) or concentrated surface runoff during heavy rainfall events. Point (municipal) sources of pollution are not present in this locality.

4.2.5 Measures to Stabilize the Water Regime and Improve Water Quality

The proposed measures for this locality reflect the absence of regular surface or drainage inflow of exogenous water into the site, as well as recommendations from the Initial Care Plan and revitalization proposals that mainly aim to remove excess biomass through appropriate management, thereby improving water quality in terms of pollution from decaying biomass.
Given the lack of continuous surface inflow of polluted water into the lake, the most effective measure to protect water quality from agricultural non-point sources is the conversion of arable land to permanent grassland. The ideal solution to prevent erosive runoff and associated particles from entering the lake would be to establish grassland along the northern and western edges of the lake, extending to the irrigation canal. Considering the property and user rights in the area, the solution presented in Figure 18 has been proposed. Measure HEV 1 consists of a protective grass strip covering 1.29 ha on parcel no. 1233, owned by the State Land Office. Measure HEV 2 targets a part of parcel no. 1231, owned by AGRO Jevišovice, a.s., involving the conversion of 4.31 ha of arable land into permanent grassland for extensive grazing.
In connection with revitalization activities planned in the southern part of the site, partial revitalization of the drainage channel is proposed (measure HEV 3), which drains excess water from the locality. This channel is listed in the watercourse database (IDVT: 10201550) and is managed by the Morava River Basin Authority (Povodí Moravy, s. p.). The land on which the stream flows is state-owned and administered by Lesy České republiky, s.p. The measure involves cleaning the channel of excess vegetation and potentially shallowing it to ensure its hydrological function remains limited to discharging surplus water from the lake rather than excessive drainage.
Measure HEV 4 proposes a regulatory structure at the lake’s outflow. Since Hevlínské jezero can receive excess water from the irrigation network during the vegetation period, it is advisable to build a regulation structure as part of the revitalization efforts. This would allow surplus water to be released during wet periods and retained during dry periods, thus maintaining adequate water levels in the locality.

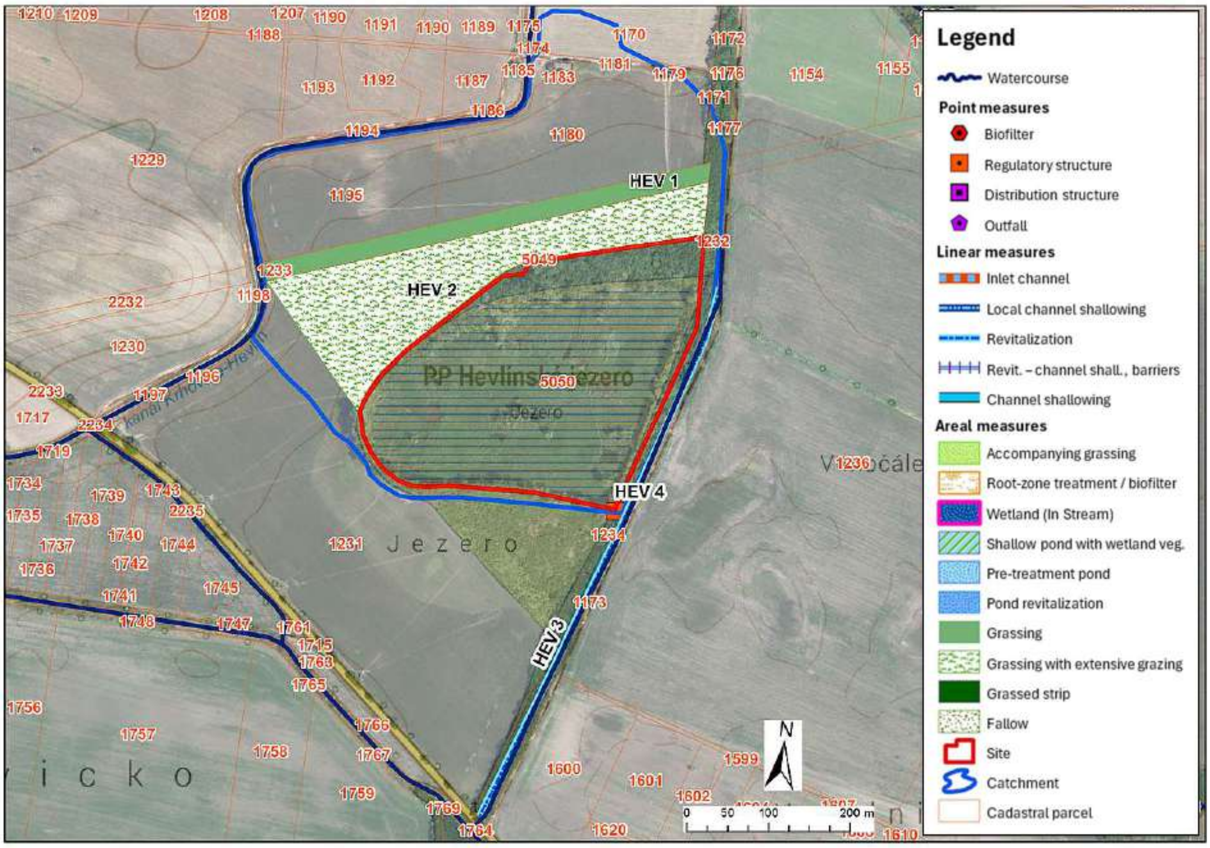

Figure 18: Overview of measures proposed in the catchment area of SAC Hevlínské jezero

4.3. SAC TRÁVNÍ DVŮR

Trávní dvůr (Fig. 19) is a Special Area of Conservation (SAC) located in the Pannonian biogeographical region in the Znojmo district of the South Moravian Region. Covering an area of 325.8144 ha, it is part of the NATURA 2000 network under the code CZ0623046. The site is protected as a national nature monument (Natural Monument – NM). It is especially significant for the conservation of mixed ash-alder alluvial forests and the presence of endangered species such as the fire-bellied toad (Bombina bombina) and the weatherfish (Misgurnus fossilis).

Figure 19: View of SAC Trávní dvůr (February 2025)

4.3.1. Site Description and Contributing Catchment

Trávní dvůr is a spatially extensive site forming part of the Dyje River's lowland floodplain. It lies at an elevation of 175 to 183 m and stretches approximately 6 km between the towns of Hevlín and Jevišovka along the Austrian border. The area consists of riparian forests with remnants of oxbow lakes and seasonal pools, wetlands, aeolian sands buried along the floodplain edges, remnants of original floodplain meadows, saline habitats, agricultural fields, and drainage canals.

Geomorphologically, the site belongs to the Dyje-Svratka Floodplain (subunit), itself a component of the Dyje-Svratka Depression within the Western Outer Carpathian Depressions. The catchment area of the SAC falls within the Drnholec Upland, a subunit of the same geomorphological complex.

From a geological perspective, both the SCI and its catchment are predominantly composed of Pleistocene to Holocene sedimentary rocks (Fig. 20), part of the Bohemian Massif cover formations and post-Variscan migmatites. The SCI consists of unconsolidated fluvial alluvial deposits, including clay, sand, and gravel. These are underlain on the western side by additional fluvial sands and gravels, with some areas featuring finer deluvio-fluvial sediments.

The site includes extensive areas without defined soil types (wetlands and forests). The remaining areas are covered by modal and gleyic fluvisols – 0.58.00 and 0.59.00, classified into hydrological groups C and D, indicating low to very low infiltration capacity. In the wider catchment, chernozems (0.05.01 and 0.04.01) are predominant, with regosols occurring in areas with deluvio-fluvial sediments. The soil cover is illustrated in Fig. 21.

Hydrologically, the site lies within the Dyje floodplain, which was regulated as early as the mid-19th century. As a result of the construction of large levees, the river lost its connection to the original floodplain, leading to the desiccation of wetland areas. The Anšovský stream (IDVT: 10205937, length: 8.1 km) flows through the southern part of the site. The northern part is bordered by the Hrabětický stream (DVT: 10192119), a short (3 km) channelized stream functioning as a main drainage facility (HOZ).

A key water source for the Hrabětický stream—and thus for the entire site during the vegetation season—is the Krhovice–Hevlín irrigation canal (IDVT: 10441660), a 24 km long canal operated by Závlahy Dyjákovice, s.r.o. The SCI is interlaced with a network of drainage canals that serve alternating functions of irrigation and drainage. According to the ISVS database, there are four independent watercourses within the site without designated administrators.

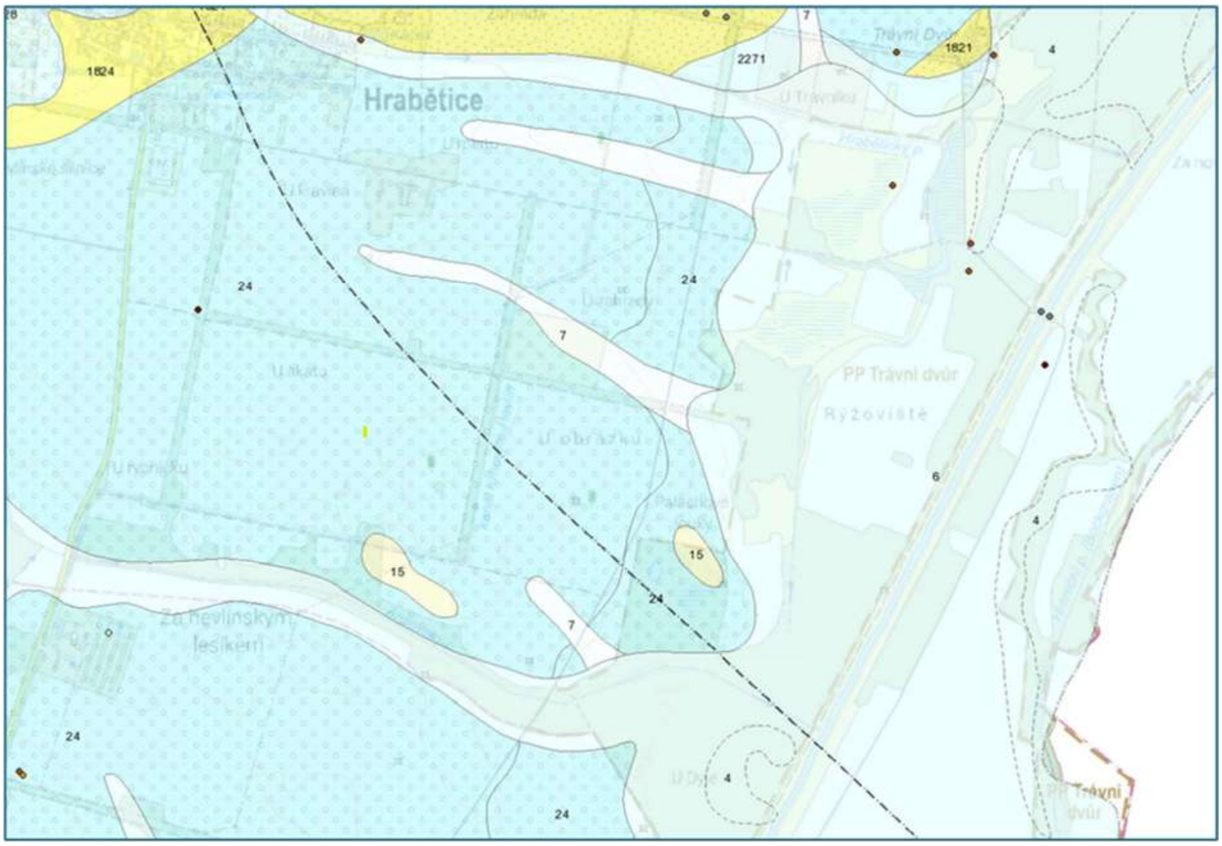

Figure 20: Geological composition of SAC Trávní dvůr (ČGS database); 4, 6 - alluvial sediment (clay, sand, gravel), 7 - mixed sediment (mostly fine-grained), 15 - silty sand (quartz), 24 fluvial unconsolidated variegated sediment (sand, gravel), 1824 - calcareous clay (shale) with positions of calcareous sands and gravels

Geomorphologically, the site belongs to the Dyje-Svratka Depression. It is underlain by young alluvial sediments (clayey and sandy), with tertiary sands and clays occasionally appearing at shallow depths, particularly at the western edge of the site. The dominant soil types are modal and gleyic fluvisols, occasionally supplemented by gleysols and stagnogleys. The area lies in a warm climatic region characterized by very long, hot, and dry summers. Phytogeographically, the site is part of the thermophyticum region, specifically the Dyje-Svratka Depression subdistrict (18a).

4.3.2. Main Ecological Challenges

The principal ecological issue in the Trávní dvůr locality is the regulation of the water regime. Drainage and river engineering interventions along the Dyje have led to a decline in the groundwater table, adversely affecting wetland habitats and reducing their biological value. As a result, species diversity in the area has decreased. Additionally, the expansion of invasive species threatens the stability of the native ecosystems.

4.3.3. Pollution Source Analysis

The Trávní dvůr SCI, with a core area of 257.3 ha, has a large contributing catchment area of 5,348.8 ha (Fig. 22). This catchment is intensively used for agriculture, with agricultural land occupying 78.6 % of the area, and arable land accounting for 70.8 % (according to LPIS). The area is also extensively drained, with the ZVHS database recording agricultural drainage structures on 149.7 ha. Remote sensing analyses (DPZ) have revealed several additional drainage structures across the catchment (Fig. 23). In addition to diffuse agricultural drainage, a substantial number of linear drainage structures—main drainage facilities (HMZ), both open and piped, as well as irrigation canals—are recorded in the State Land Office database (https://geoportal.spucr.cz/). The most significant of these is the Krhovice–Hevlín canal. West of the village of Velký Karlov, an open main irrigation canal (NÁHON N2 + ČS VALTROVICE) runs for 6.5 km, nearly the entire length of which lies within the site's catchment. Other structures include piped and open HMZ and HOZ systems. The total length of registered drainage canals in the catchment is 164.5 km. The natural hydrological network consists mainly of the Hrabětický stream in the north and the Anšovský stream in the south. Several large fishponds (Kačák, Zelmaňák, Nekvasilák) are also located in the Hrabětický stream catchment.

In terms of municipal pollution sources, the catchment includes the municipalities of Šanov, Hrabětice, Velký Karlov, and Valtrovice-Sídliště, all of which are sewered (Fig. 23). The Šanov wastewater treatment plant (WWTP) is a mechanical-biological facility with nitrification and denitrification, nitrogen and phosphorus removal, aerobic sludge stabilization, gravity sludge dewatering, and sludge storage, which has been in permanent operation since 2001 and was last upgraded in 2016. The WWTP serves 2,613 PE and discharges approximately 88 kg of ammonium nitrogen ($N\text{-}NH_4$) and 11 kg of total phosphorus per year. The outflow is directed into a HOZ that feeds into the Anšovský stream, potentially introducing pollutants into the southern part of the SAC. In the settlements of Dvůr Anšov and Karlov, there is no sewerage system. Domestic wastewater is treated locally at the source, partially in septic tanks and partially stored in cesspools. Overflow from these structures is often discharged into surface ditches or infiltration systems, which then carry the wastewater into local watercourses. In rare cases, the contents of cesspools are spread on fields. Another significant point source of pollution is a cannery located in the northwestern part of the site, whose wastewater is discharged into the Hrabětický stream. This facility may pose a major risk to water quality in the northern section of the SAC. Based on this analysis, water quality in the Trávní dvůr site is threatened by both diffuse agricultural pollution and point sources of municipal and industrial origin.

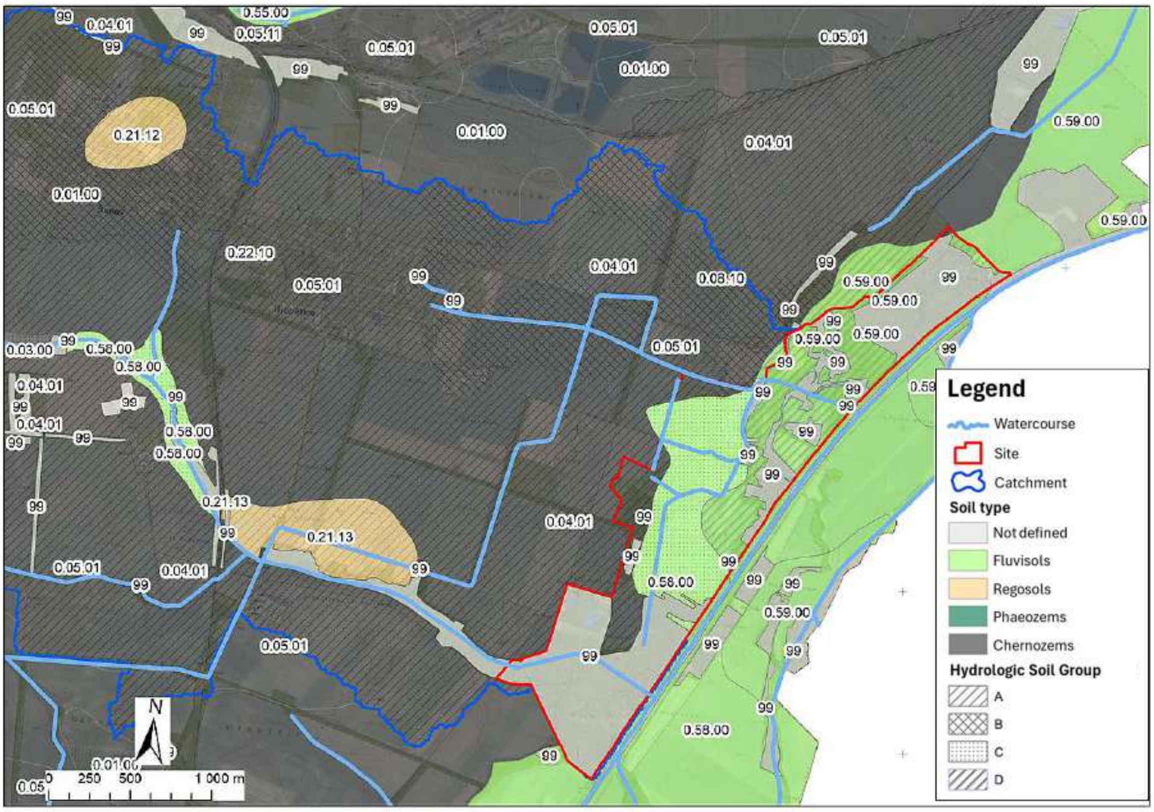

Figure 21: Soil cover in the area of SAC Trávní dvůr

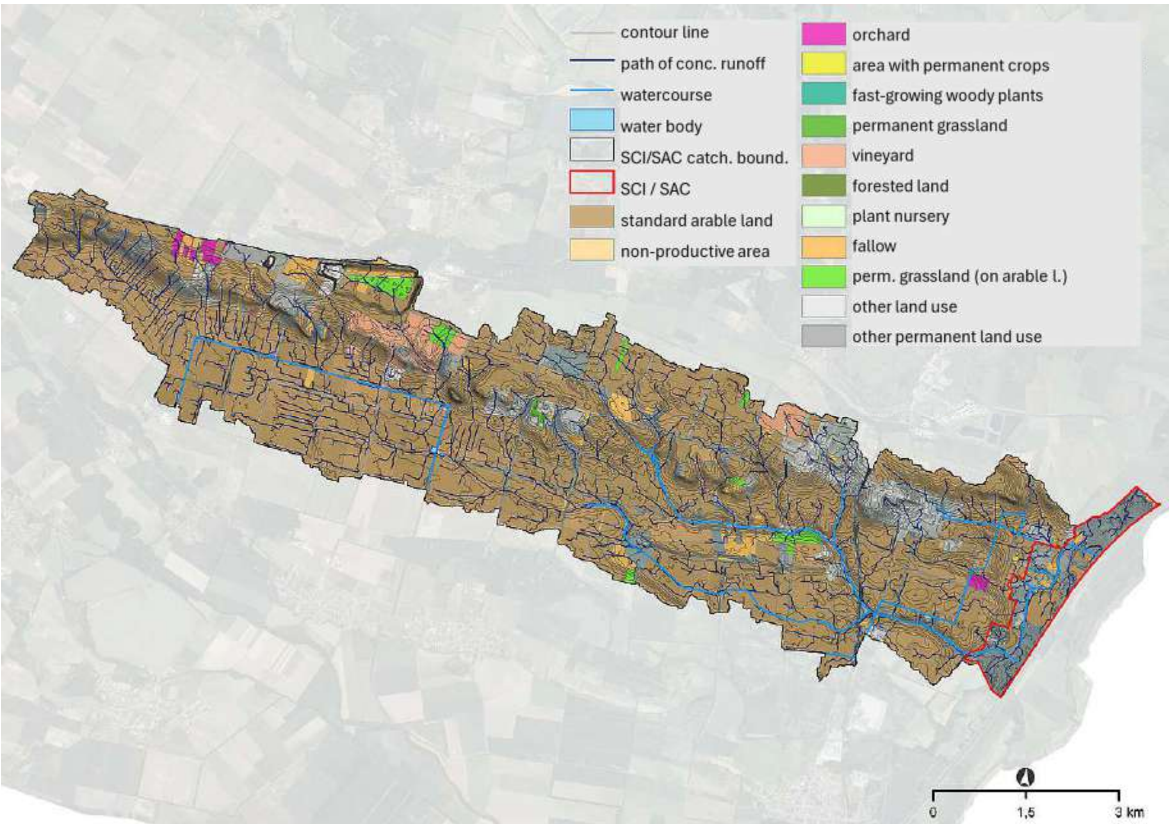

Figure 22: Land use in the SAC catchment area Trávní dvůr

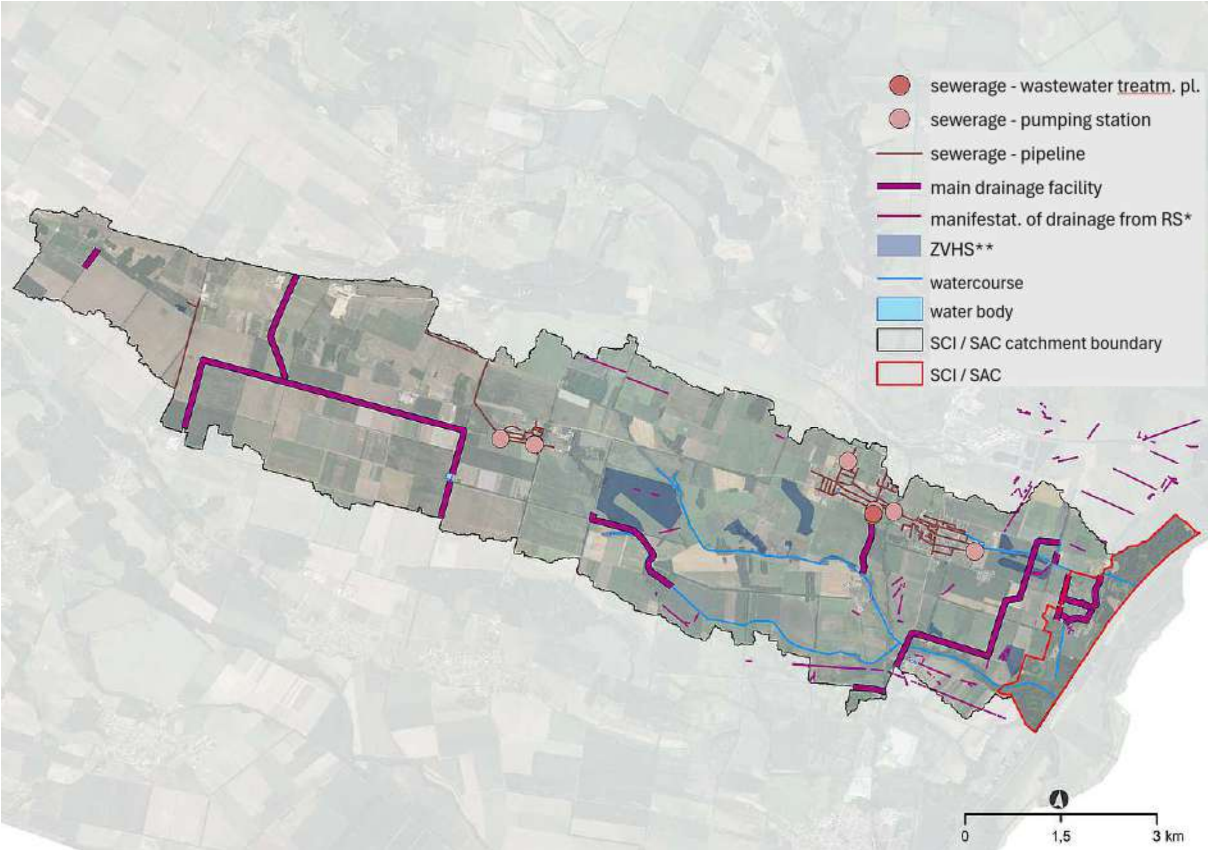

Figure 23: Sources of water pollution in the SAC catchment Trávní dvůr
**RS – Remote Sensing; **Former Agricultural Water Management Administration (in Czech ZVHS)*

4.3.4. Water Quality in the SAC Trávní dvůr

Within the Trávní dvůr SAC, water quality monitoring was primarily conducted on the Hrabětický stream, which represents one of the main water inputs to the site. A screening sample was also taken from a monitored pond in the Rýžoviště locality. These monitoring profiles lie within a catchment featuring extensive drainage, including main drainage structures (HOZ) such as open and piped HZZ and open HOZ channels, along with sewerage infrastructure including pumping stations and the Šanov WWTP. Additional samples were collected from the Hrabětický stream downstream of the cannery outfall.

Hrabětický potok

The water in the Hrabětický stream was characterized by relatively low salinity (average sulfate concentration of 151 mg/l and chloride concentration of 49 mg/l). However, it exhibited significant contamination with ammonium ions (average 2.65 mg/l), corresponding to class V water quality. Nitrate concentrations, on the other hand, remained low. Phosphorus loading was significant, particularly in terms of total phosphorus, with average concentrations of 1.23 mg/l also corresponding to class V. The stream showed high organic pollution, as indicated by average organic carbon (C_org) concentrations of 74.65 mg/l and chemical oxygen demand (COD_Cr) values averaging 50.36 mg O_2/l, corresponding to class IV water quality.

During four monitoring campaigns, concentrations of pesticides and their metabolites were also determined (Table 7). The total concentration of pesticide substances (Fig. 24) in the Hrabětický stream ranged from 1.6 to 2.0 µg/l. The 29 detected compounds were dominated by metabolites (89–99% of the total). These findings are consistent with typical pesticide mixtures in small streams flowing through agricultural landscapes in the Czech Republic, with concentrations comparable or lower (Konečná et al., 2023). The main substances included metabolites of chloroacetanilide herbicides (metolachlor, metazachlor), chloridazon metabolites, and the glyphosate metabolite AMPA. Among parent substances, glyphosate, chlorotoluron, and dinoterb were detected, though only at nanogram-per-liter levels.

Trávní dvůr – below the Cannery Outfall

The water quality at the profile downstream of the cannery outfall reflected the input of additional organic wastewater into an already significantly polluted stream. COD_Cr values were the highest among all profiles, averaging 493.7 mg O_2/l (class V). Other parameters showed slightly lower concentrations compared to the upstream profile, suggesting some dilution. In terms of salinity, the water was classified as polluted (class III for sulfates), while chloride concentrations remained similar to upstream and fell into class I.

Trávní dvůr – tůň Rýžoviště (Pond)

The water in the monitored pond displayed higher salinity (average sulfate 323 mg/l, chloride 79 mg/l). Total phosphorus concentrations were elevated (average 0.95 mg/l), corresponding to class V. Likewise, COD_Cr values (average 80.4 mg O_2/l) and C_org (average 17.04 mg/l) indicated high organic load, corresponding to classes V and IV, respectively. Ammonium ion concentrations were significantly lower than in the Hrabětický stream (0.25 mg/l), and nitrate concentrations remained low (5.0 mg/l). During the pesticide application season, a screening of pesticide concentrations was conducted, revealing some influence from agricultural spraying. However, pesticide concentrations were relatively low (total 0.90 µg/l), and the composition was dominated by common metabolites such as those of chloridazon, chloroacetanilide herbicides, and AMPA. Glyphosate was the most prominent parent substance, detected at only 0.026 µg/l.

Summary of Water Quality Findings

The detected pollution in the Trávní dvůr SCI is most likely of municipal origin (elevated ammonium nitrogen concentrations), while the lower section of the Hrabětický stream is also influenced by industrial discharges from a nearby food processing facility (as evidenced by high COD_Cr values). The elevated concentrations of organic matter in the Rýžoviště pond likely result from decaying biomass, although some phosphorus pollution may also be attributed to the Anšovský stream, which carries municipal wastewater. Regarding heavy metals, the SAC can be considered unpolluted, as all measured concentrations during the winter sampling were below detection limits or just above them, while summer concentrations fell within class I and II.

Table 6: Average values of monitored water chemical indicators at SAC Trávní dvůr

Parameter / profile	CON (mS/m)	$CHSK_{Cr}$ (mg/l)	Corg (mg/l)	Chlorides (mg/l)	Sulphates (mg/l)	$N\text{-}NH_4^+$ (mg/l)	$N\text{-}NO_3^-$ (mg/l)	N org. (mg/l)	$P_{tot.}$ (mg/l)	PO_4 (mg/l)
Hrabětický potok	80	50,4	74,65	49	151	2,06	3,11	6,32	1,23	0,24
Hrabětický p. - pod výustí	28	493,7	8,43	78	190	0,09	5,00	3,25	0,22	0,10
Travní dvůr – tůň Rýžoviště	102	80,4	17,04	79	323	0,19	1,12	2,58	0,95	0,96

(Classification according to Surface water quality classification: ČSN 75 7221–Klasifikace kvality povrchových vod. Úřad pro technickou normalizaci, metrologii a státní zkušebnictví, 2017)

I	Unpolluted water
II	Slightly polluted water
III	Polluted water
IV	Heavily polluted water
V	Severely polluted water

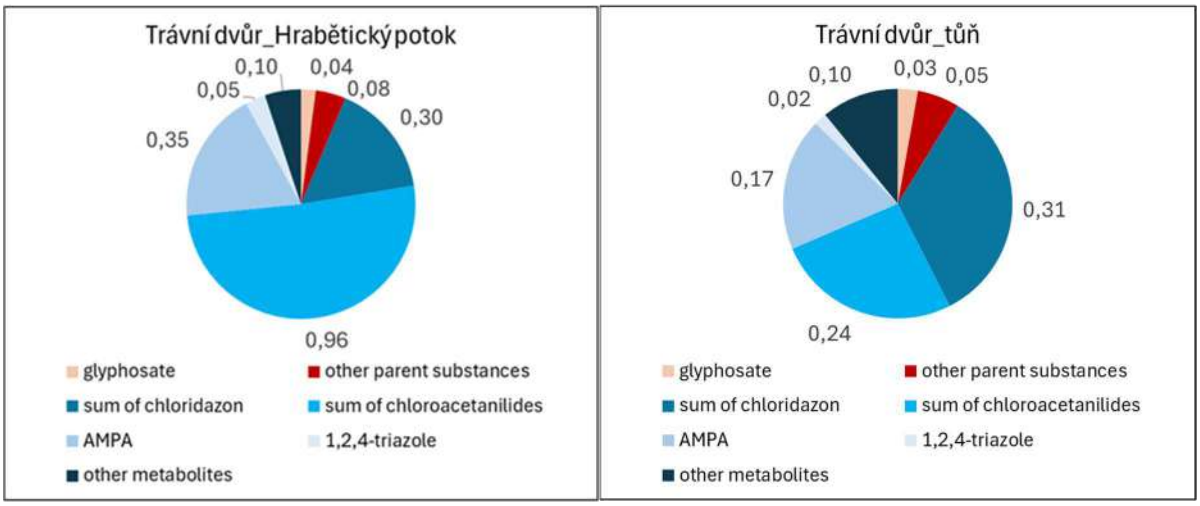

Figure 24: Composition of Pesticide and Metabolite Concentrations in the Trávní dvůr SAC Waters

Table 7: Results of Pesticide Monitoring in Trávní dvůr SAC

Profile	samples (n)	Detected compounds (n)	Total concentration (μg/l)	Pesticide parent compound with the highest concentration (μg/l)	Metabolite of the pesticide with the highest concentration (μg/l)
Hrabětický potok	4	29	1,6 - 2,0	glyphosate (0,04)	metazachlor ESA (0,5)
tůň (Rýžoviště)	1	15	0,9	glyphosate (0,03)	Chloridazon metabolites (0,3)

4.3.5. Measures to Stabilize the Water Regime and Improve Water Quality

An overview of the proposed measures is presented in Fig. 25, with a detailed view of the Hrabětický stream area in Fig. 26.

TRA 1 – Grassland Establishment with Extensive Grazing

This measure involves converting 10.9 ha of arable land into grassland with extensive grazing—or alternatively, into fallow land with natural succession and grazing. The arable land directly adjacent to the wetland pond has a strongly negative impact on water quality, especially when high-risk crops like maize are cultivated. From a water protection perspective, establishing permanent grassland regularly grazed to maintain wetland habitats is optimal. As an alternative, fallow land with grazed successional vegetation and occasional ploughing is proposed. The affected land parcels (6403/1 and 6403/2), although located within the protected area, are privately owned (see Table 28). If a land-use change (or purchase) is not feasible, the measure may at least be partially implemented through organizational approaches—e.g., by using crops and management practices that minimize nutrient and especially pesticide application.

TRA 2 – Partial Grassland Conversion of Arable Land Block

This measure follows from TRA 1. It proposes converting 13.8 ha of arable land within block 6403 and part of block 6403/1 into permanent grassland. If a change in land use (or land acquisition) cannot be achieved, a partial implementation through minimized nutrient and pesticide application is again recommended.

TRA 3 – Grassland Conversion of Arable Block

This measure proposes grassing over 5.9 ha of arable land in block 6404/6 to prevent the input of nutrients and pesticides into the adjacent wetland. Given the relatively complex land ownership structure (the measure affects six different parcels—see Table 2), implementation may be challenging. As an alternative, organizational measures using low-input cropping practices should be considered.

TRA 4 – Conversion of Arable Land into Fallow Land

The objective of this measure is to extend the existing fallow area in the Maňasova Špice locality to a portion of parcel no. 12776. The area, covering 2.2 ha, will be maintained through mowing or grazing. The primary purpose is to prevent pollutant input into the waterlogged area on parcel no. 12777.

TRA 5 – Grassland Establishment on Part of a Land Parcel

This measure involves converting a 2.0 ha portion of land block 6407/1 into grassland. The main objective is to prevent pollutant runoff into the waterlogged area on parcel no. 12777 and into the Hrabětický Stream. The optimal solution is to reclassify the arable land into G-type land (permanent grassland on arable soil), which would be periodically ploughed. Due to the proximity of an orchid habitat (Dactylorhiza species), it is necessary to apply an appropriate mowing regime that does not disturb this vegetation.

TRA 6 – Grassed Buffer Strip

This measure consists of establishing a grassed buffer strip along the drainage canal on the western edge of the SAC. Its aim is to prevent contamination of the canal by runoff from adjacent arable land. The measure is divided into three sections due to intersection with a field road and adjacent areas. The actual width of the buffer strip will be determined based on the working width of the agricultural machinery used for management (typically 18 or 24 m). Given the complex land ownership structure (Fig. 25, Table 8), the optimal implementation strategy is temporary reclassification of the arable land into permanent grassland (G-type under LPIS).

TRA 7 – Constructed Wetland in the Watercourse Channel

This measure proposes the construction of a flow-through artificial wetland/root zone treatment system directly within the Hrabětický Stream channel (parcel no. 12818, state-owned). The objective is to reduce pollution levels in the stream. Constructed wetlands are among the most effective nature-based solutions for reducing nutrient and pesticide residue concentrations. In this case, given the spatial and property constraints, an in-stream solution has been proposed, whereby all stream water flows through the wetland. Water flow is slowed, allowing contact with wetland plant roots and associated microbial biofilms to facilitate pollutant degradation. Specific design parameters will be determined during the detailed project planning stage.

TRA 8 – Desilting of Drainage Canal

This measure involves desilting (and accompanying cleaning) of the drainage canal bed along a 620 m section. The desilting will restore hydrological connectivity and prevent excessive drainage of the target area. The drainage canal (IDVD 10188954) is classified as a miscellaneous watercourse with no designated watercourse administrator. All potentially affected parcels are owned by the state or the municipality.

TRA 9 – Desilting of Drainage Canal

This measure also involves desilting (and cleaning) a 420 m section of another drainage canal. Parcel no. 12747 is owned by the municipality of Hrabětice; the drainage canal (IDVT 10206292) is likewise classified as a miscellaneous watercourse with no designated administrator.

TRA 10 – Desilting of Watercourse Channel

This measure entails desilting the lower section of the Hrabětický Stream (IDVT: 10192119). The activity will restore hydrological connectivity and prevent over-drainage of the area. Parcel no. 12818, where the streambed lies, is owned by the municipality of Hrabětice, and the watercourse is administered by Povodí Moravy, s. p. The proposed constructed wetland divides the desilting into two sections with a total length of 521 m.

TRA 11 – Stream Revitalisation

This measure aims to revitalise a 550 m section of the Hrabětický Stream, from the discharge point of the cannery to its confluence with the Dyje River. The intention is to complement the planned revitalisation of the Dyje. The measure affects only public and municipal lands. If implemented, the stream revitalisation should ideally be accompanied by an additional in-stream constructed wetland located downstream of the cannery wastewater outlet.

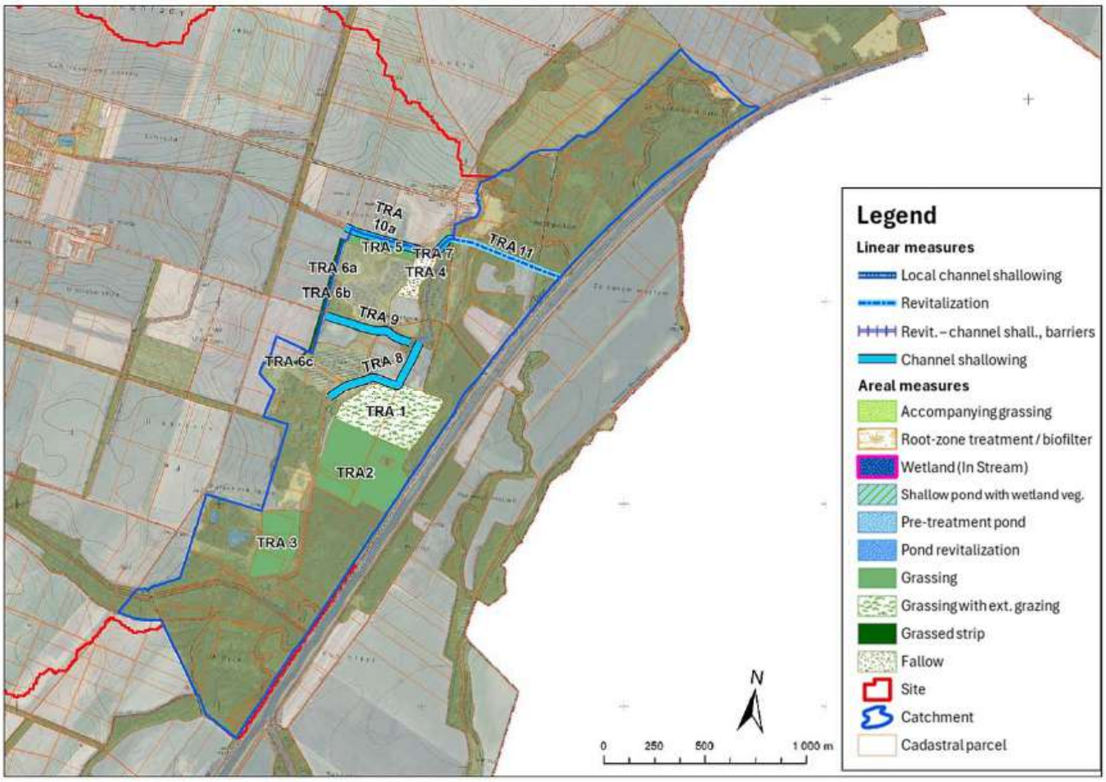

Figure 25: Overview of measures proposed in the catchment area at SAC Trávní dvůr

Table 8: Overview of the land affected by the proposed measures in SAC Trávní dvůr (k.u. Hrabětice)

measure	type of measure	parcel	land use	type of ownership
TRA 1	Grassland establishment with extensive grazing	12802	Other land	Hrabětice municipality
		12799	Arable land	Legal entity
		12807	Arable land	Natural person
TRA 2	Grassland establishment	12805	Arable land	Natural person
		12799	Arable land	Natural person
		12800	Arable land	Legal entity
		12801	Arable land	Legal entity
		12802	Other land	Hrabětice municipality
TRA 3	Grassland establishment	12741	Arable land	Natural person
		12742	Arable land	Natural person
		12743	Arable land	Natural person
		12745	Arable land	Natural person
		12750	Arable land	Natural person
		12751	Arable land	Natural person
TRA 4	Fallow	12776	Arable land	Legal entity
TRA 5	Grassland establishment	12776	Arable land	Legal entity
TRA 6	Grassed strip	12772	Arable land	Natural person
		12775	Arable land	Legal entity / Natural person
		12773	Arable land	Legal entity / Natural person
		12768	Arable land	Legal entity
		12769	Arable land	Legal entity
		13056	Arable land	Legal entity
		13057	Other land	Legal entity
		13058	Other land	Natural person
TRA 7	Constructed wetland	12818	Watercourse channel	State
TRA 8	Desilting of a drainage channel	12747	Watercourse channel	State
		12808	Waterlogged area	State
		12809	Other land	State
		12798	Permanent grassland	State
TRA 9	Desilting of a drainage channel	12747	Watercourse channel	Hrabětice municipality
TRA 10	Channel desilting	12818	Watercourse channel	Hrabětice municipality
TRA 11	Stream channel restoration	11194	Watercourse channel	State
		12023	Watercourse channel	Hrabětice municipality

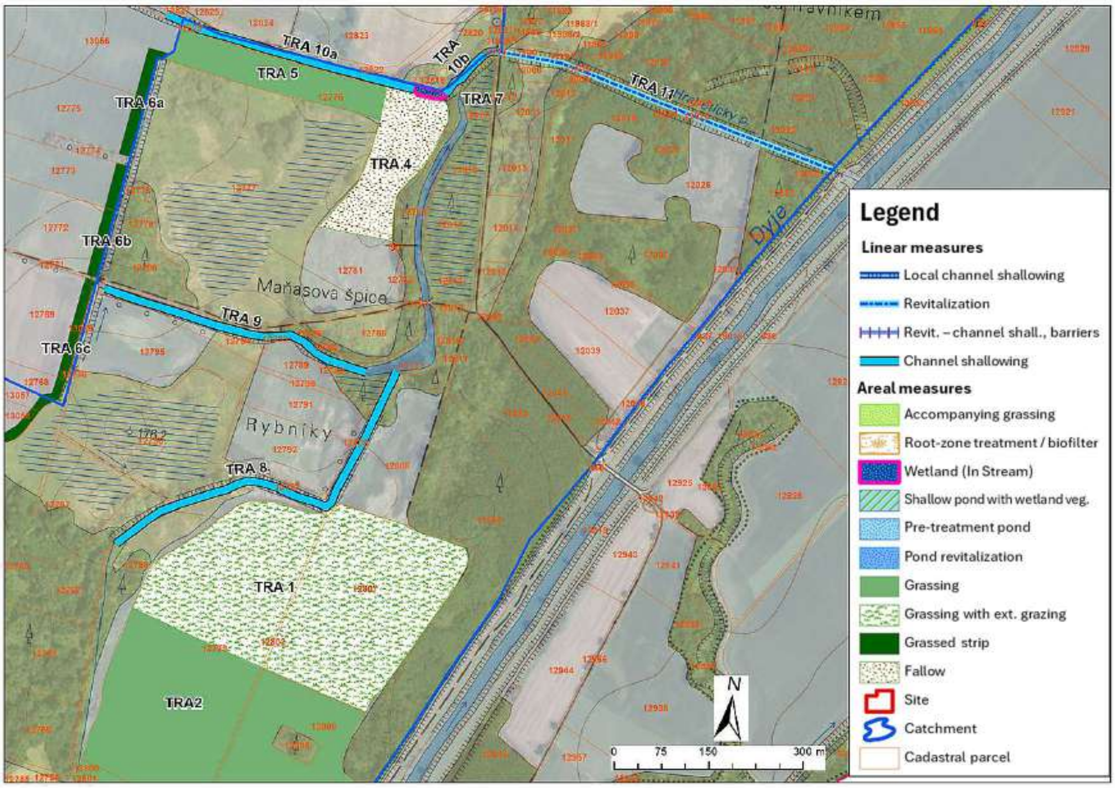

Figure 26: Overview of measures proposed in the catchment area of the SAC Trávní dvůr in the locality of Hrabětický potok

4.4. SAC Slanisko Novosedly

The Slanisko Novosedly site (Fig. 27) is situated within the NATURA 2000 Special Area of Conservation (SAC) designated as CZ0620187, covering an area of 2.085 ha. It lies within the Pannonian biogeographical region in the Břeclav District, South Moravian Region. It falls under national protection as a Natural Monument (NM). The site is primarily significant due to the presence of inland salt marshes (habitat code 1340*), which are classified as priority habitats under the NATURA 2000 network.

Figure 27: View of the Slanisko Novosedly SAC (June 2024)

4.4.1 Site Description and Contributing Catchment

The Slanisko Novosedly site is located on the northeastern edge of the municipality of Novosedly (Břeclav District). From a geological perspective (Fig. 28), the site consists of uncemented fluvial sediments with a varied mineralogical and granulometric composition (sand, gravel). These Pleistocene-aged sediments belong to the geological unit of the Bohemian Massif – cover formations and post-Variscan migmatites. To the east, these alluvial deposits transition into uncemented deluvial sediments composed of stony to loamy-stony material of the same unit. At the eastern watershed of the site's catchment, uncemented clastic sediments (sands, gravels with consolidated sandstone and conglomerate layers) of the Carpathian Foredeep can be found.

The soil cover (Fig. 29) within the SAC is represented by fluvisols (soil type 0.58.00), while the majority of the catchment area is covered by chernozems (0.04.04). Regosols (0.21.53) occur only in the highest parts of the catchment along the watershed divide.

Geomorphologically, the site belongs to the Dyje-Svratka Alluvial Plain microregion, part of the Dyje-Svratka Alluvial Plain subunit, and the Dyje-Svratka Depression unit (Western Outer Carpathian Sub-province). The eastern portion of the catchment is part of the Fore-Dunajovice Ridge microregion, within the Dunajovice Hills subunit and the same larger unit and sub-province.

The Slanisko Novosedly site lies within the catchment of the Pokran Stream (IDVT 10203157), a right-bank tributary of the Polní potok (Mikulovka). The SAC itself does not receive any surface water inflow. A seasonal pool located approximately in the centre of the site is fed by groundwater and precipitation, with its size fluctuating considerably throughout the year. At the northern edge of the SAC, a system of pools of varying depth was created as part of a revitalisation project; these pools are drained into the Pokran Stream.

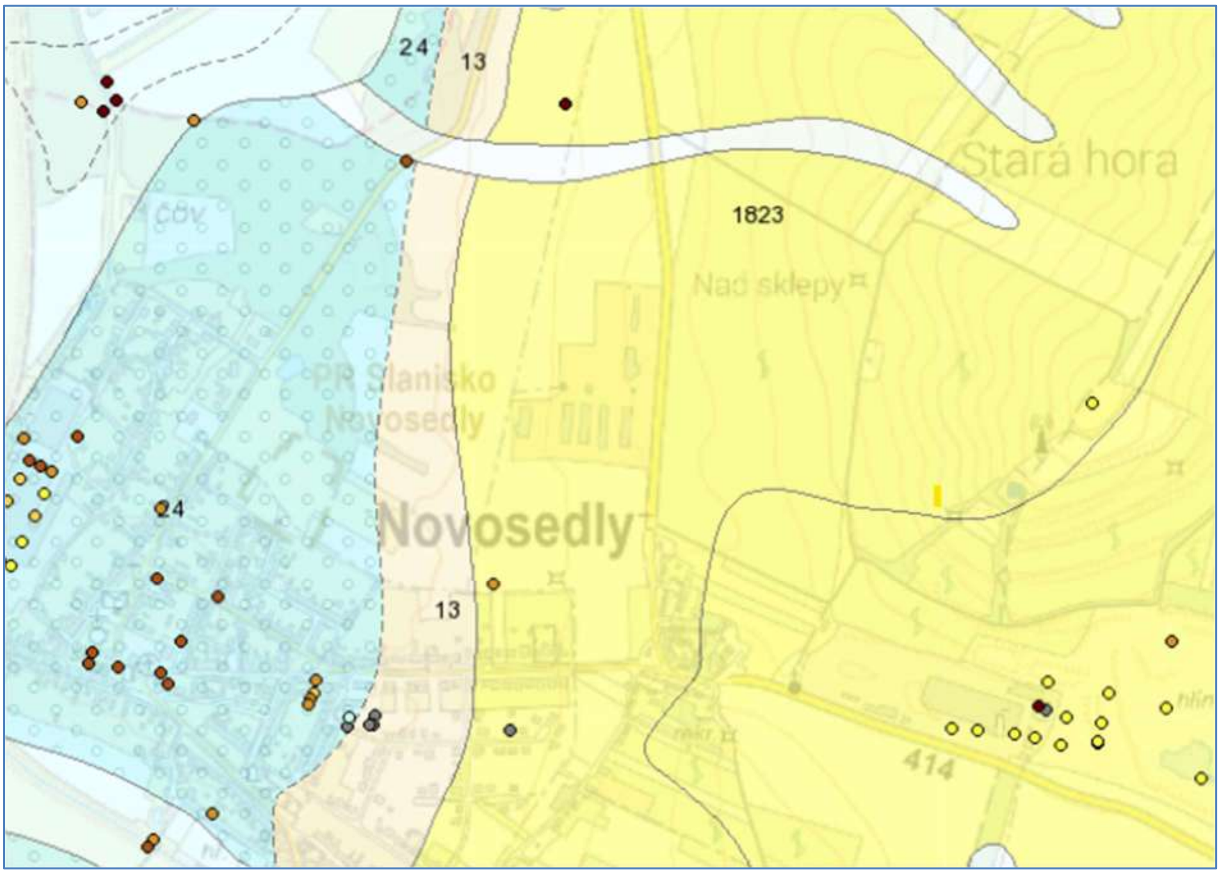

Figure 28: Geological composition of SAC Slanisko Novosedly (base map: CGS); 13 – deluvial uncemented sediment, 24 – fluvial uncemented sediment (sand, gravel, stony to loamy-stony), 1823 – marine sediment (clastics – sands, gravels with consolidated sandstone, conglomerates)

4.4.2. Main Ecological Challenges

The primary ecological challenges include maintaining the water regime in the seasonal pool and managing the encroachment of halophytic areas by expansive and invasive species. Alterations to the water regime—mainly due to historical wetland drainage and groundwater extraction for settlement purposes—have led to a decline in populations of critically endangered halophytes. Reintroduction of traditional grazing is needed to disturb the soil surface and support the growth of competitively weaker species. Currently, a potential threat to the water regime is posed by drainage through relatively deep, newly constructed pools (clearly visible in Fig. 27). The actual impact on the water regime must be verified through monitoring of water quality and groundwater levels.

4.4.3. Pollution Source Analysis

A significant portion of the catchment consists of built-up areas of Novosedly municipality. An agricultural facility is also located in the northern part. According to the LPIS (Fig. 30), 35.1% of the catchment is used for agriculture. Arable land occupies 15.6%, while the remaining agricultural areas are vineyards. The ZVHS database does not list any drainage structures within the catchment, and none were identified through remote sensing (Fig. 31).

The site has no permanent surface inflow. However, a relatively dense network of concentrated runoff paths (CRPs) converging on the SAC was generated based on a digital elevation model. These CRPs mostly traverse built-up areas, except in the northern part of the catchment, which flows into the newly revitalised area at the northern boundary of the SAC. The hydrological regime is currently influenced by the project "Restoration of Slanisko Novosedly", which aims to reestablish the natural water regime along the northern margin of the salt marsh through a system of pools. Nevertheless, the newly constructed pools may capture water from the SAC itself, potentially causing excessive drying of the site. The western and southwestern parts of the catchment are urbanised and served by a sewage network. According to VÚME (Selected Property Records) and VÚPE (Selected Operational Records), a sewage pumping station is located at the southwestern edge of the catchment. The wastewater treatment plant is situated outside the SAC's catchment and discharges into the Pokran Stream.

The most significant risk to water quality in the salt marsh appears to be surface runoff from built-up areas during major rainfall-runoff events, or accelerated runoff from agricultural land via CRPs in the northern catchment.

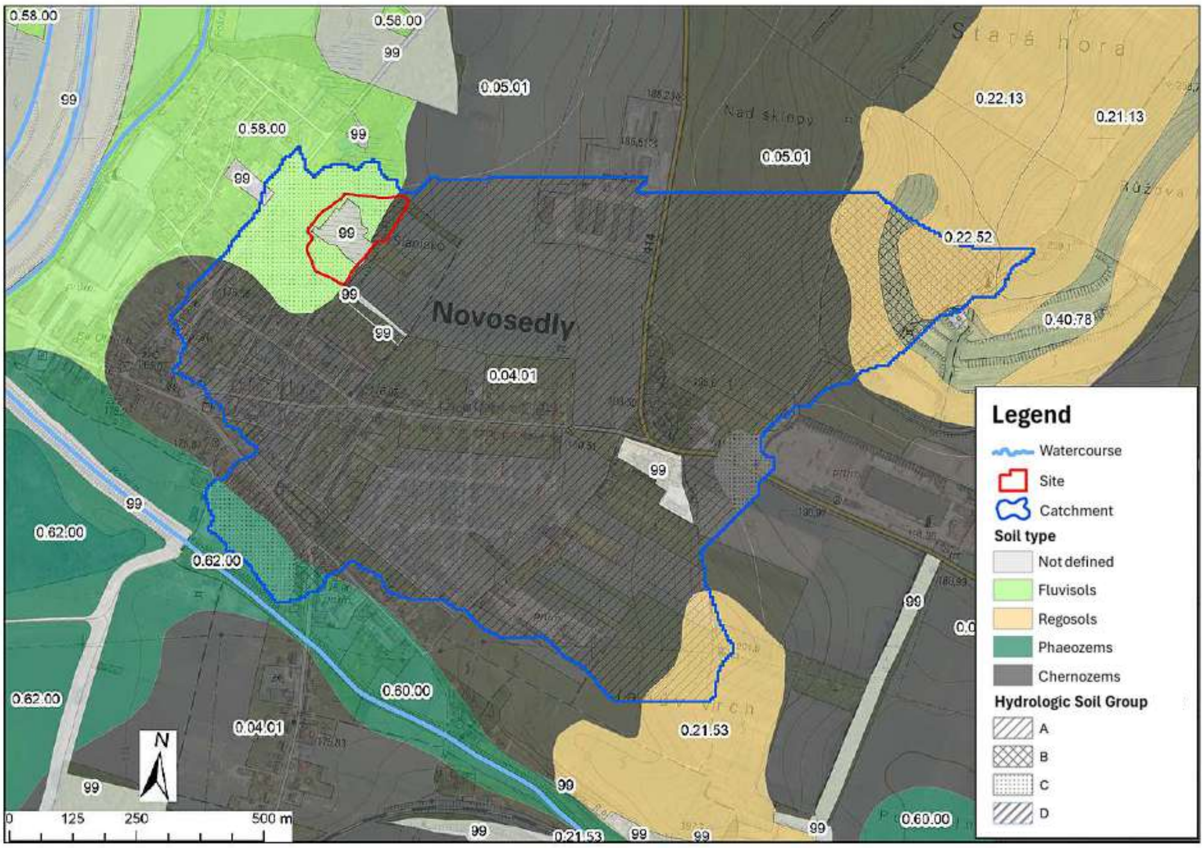

Figure 29: Soil cover of SAC Slanisko Novosedly

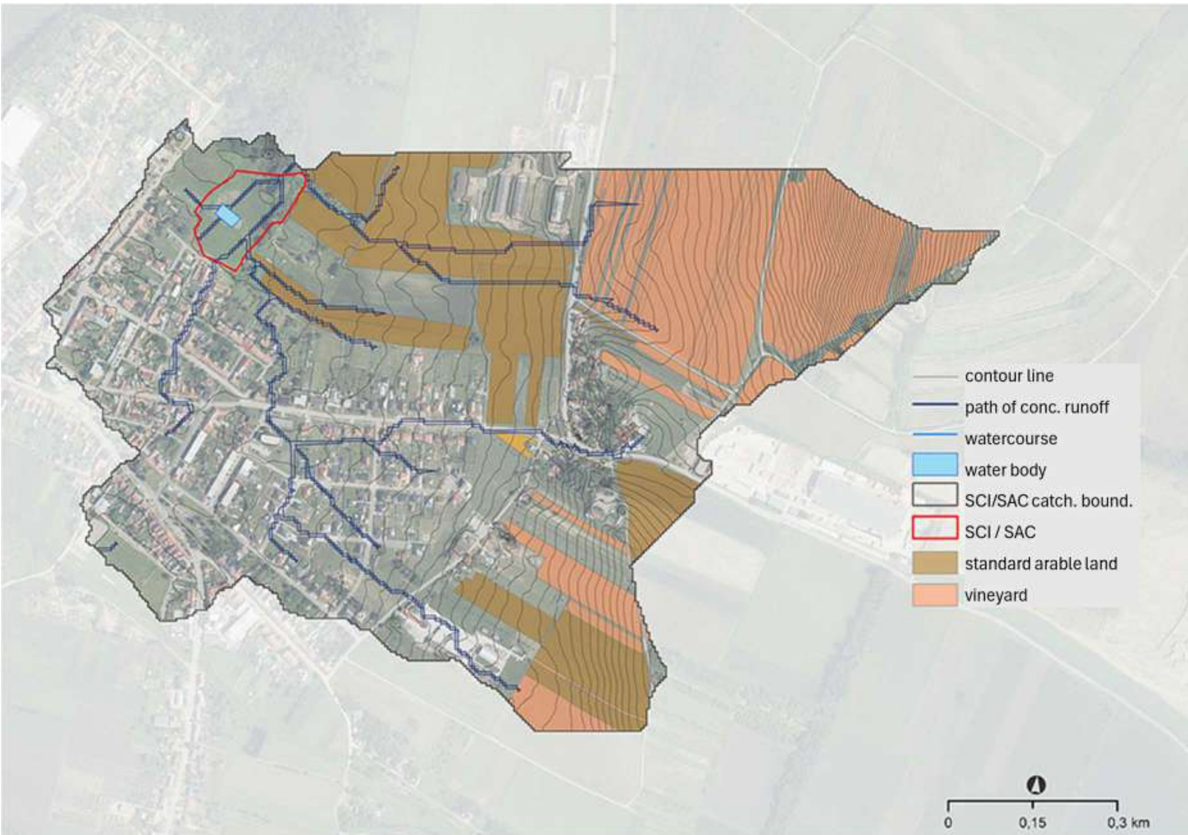

Figure 30: Land use in the catchment of SAC Slanisko Novosedly

Figure 31: Pollution sources in the catchment of SAC Slanisko Novosedly

4.4.4. Water Quality in SAC Slanisko Novosedly

Water samples were regularly collected from the seasonal pool located near the centre of the site. All samples exhibited high salinity, with an average sulphate concentration of 1,921 mg/l and chloride concentration of 298 mg/l. The high salinity correlates with high conductivity, averaging 82 mS/m. Phosphorus concentrations were relatively low: orthophosphate averaged 0.16 mg/l and total phosphorus 0.29 mg/l (corresponding to Class III surface water quality). Nitrogen compound concentrations were also low, except for organic nitrogen (average 3.23 mg/l), possibly due to decomposition of plant residues in the pool. High organic pollution is further evidenced by high average values of Corg (32.0 mg/l) and COD-Cr (124.4 mgO_2/l), placing these parameters in Class V of water quality. Due to the absence of potential pollution sources, no pesticide residues were detected.

Heavy metal concentrations in the SAC's waters were low, mostly below detection limits.

For comparison, one water sample was taken from a newly revitalised pool at the northern site edge. Concentrations of monitored substances were similar or slightly lower than in the main pool, but conductivity and COD-Cr values were higher.

Table 9: Average values of selected chemical indicators in SAC Slanisko Novosedly

Parameter / profile	CON (mS/m)	$CHSK_{Cr}$ (mg/l)	Corg (mg/l)	Chlorides (mg/l)	Sulphates (mg/l)	$N\text{-}NH_4^+$ (mg/l)	$N\text{-}NO_3^-$ (mg/l)	N org. (mg/l)	$P_{tot.}$ (mg/l)	PO_4 (mg/l)
Novosedly	82	124,43	32,00	298	1 921	0,11	0,49	3,23	0,29	0,16
Novosedly revitalizace	230	143,00	29,50	197	1 060	0,05	0,11	2,87	0,17	0,03

(Classification according to Surface water quality classification: ČSN 75 7221–Klasifikace kvality povrchových vod. Úřad pro technickou normalizaci, metrologii a státní zkušebnictví, 2017)

I	Unpolluted water
II	Slightly polluted water
III	Polluted water
IV	Heavily polluted water
V	Severely polluted water

Summary of Water Quality Monitoring Results

The monitoring results for SAC Slanisko Novosedly indicate organic pollution, likely originating from decomposing plant residues within the salt marsh. Low nitrate concentrations suggest minimal agricultural pollution, and low ammonium and phosphorus levels indicate limited municipal influence.

4.4.5. Measures to Stabilise the Water Regime and Improve Water Quality

In terms of water quality, there is no need to implement biotechnical measures in the SAC. As a preventive action, grassing of plot no. 6733 (area 0.51 ha – measure NOV 1) is recommended to improve erosion control during extreme runoff events. The plot is privately owned. Alternatively, suitable management (avoiding row crops, using winter crops or cover crops) could be applied to two adjacent soil blocks on the eastern edge of the SAC.

Another appropriate measure is NOV 2, which involves limiting the use of glyphosate for municipal land management within the municipality's cadastre. Glyphosate sprays can be replaced with alternative herbicides (e.g. Roundup Fast with pelargonic acid as a natural active ingredient) or non-chemical methods such as hot air or steam/hot water treatments. An overview of proposed measures is shown in Fig. 32.

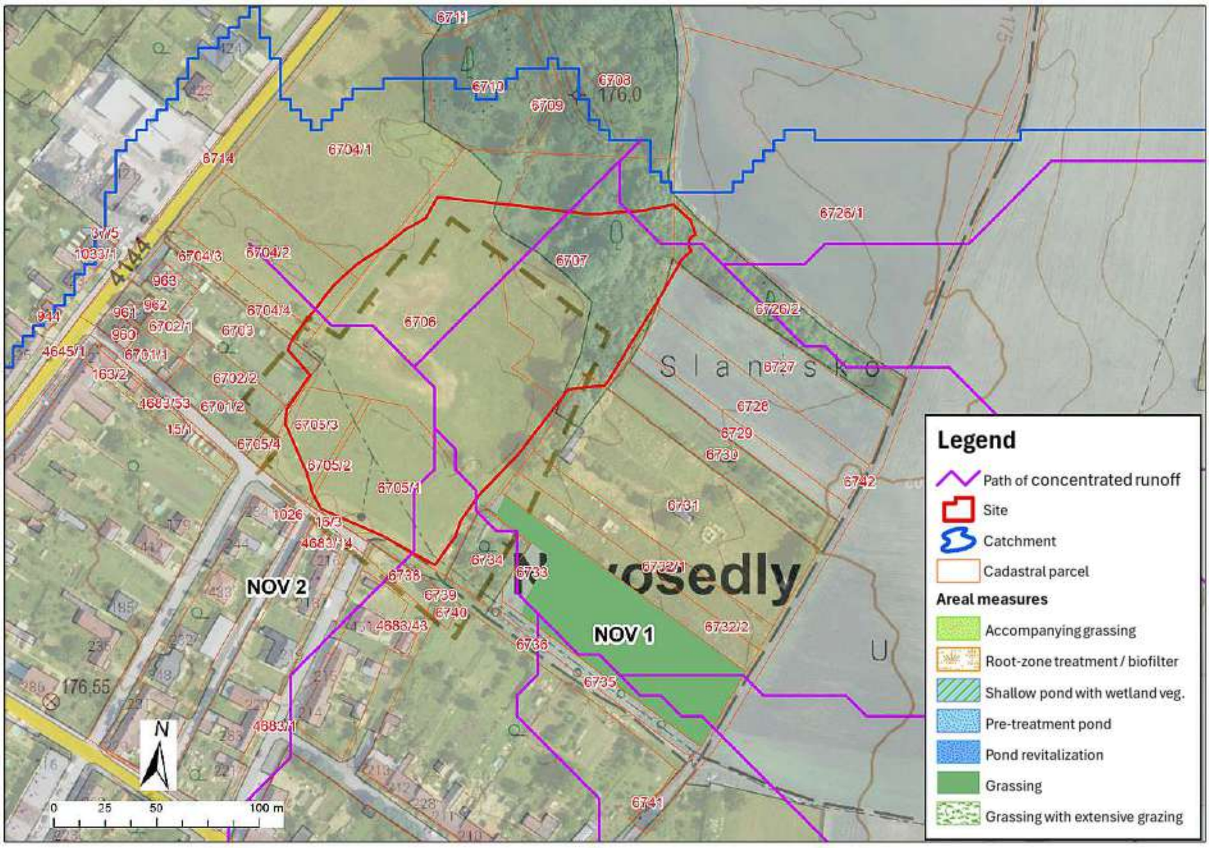

Figure 32: Overview of measures proposed in the catchment area of the Slanisko Novosedly SAC

4.5. SCI SLANISKO DOBRÉ POLE

The site Slanisko Dobré Pole (Figure 33) is a Natura 2000 Site of Community Importance (SCI), designated under code CZ0620031, with a total area of 3.696 ha. It is situated in the Pannonian biogeographical region, in the Břeclav district of the South Moravian Region. The site is protected as a Natural Monument (PP) under national legislation. Dobré Pole is of particular ecological interest due to the occurrence of halophytic plant species and salt-tolerant communities that are extremely rare within the Czech Republic.

Figure 33: View of the SCI Slanisko Dobré Pole (April 2024)

4.5.1. Site Description and Contributing Area

The core of the site consists of a saline meadow that has developed on the former location of a football field. It is a relatively small site (3.7 ha) including the contributing area. The catchment area of the SCI spans 35.9 ha and is primarily composed of built-up areas of the municipality Dobré Pole. Geologically (Figure 34), the predominant substrate of both the site and its catchment consists of unconsolidated calcareous clay (schlier) with intercalations of calcareous sands and gravels of Neogene age, within the Carpathian Foredeep region. In the northwestern part of the site, unconsolidated alluvial sediments (comprising loamy, sandy, and gravelly fractions) occur, overlain by Chernozem soils (Figure 35), classified as soil type 0.05.01. These are non-skeletal to slightly skeletal, predominantly deep soils. From a hydro-pedological perspective, they fall under group A, characterized by high infiltration rates and high water retention capacity. The soils are strongly alkaline with a high content of Ca^{2+}, Mg^{2+}, K^{+}, and SO_4^{2-}. Geomorphologically, the site lies within the Brodská depression subregion, part of the Dunajovické Hills, in the Dyje-Svratka Valley mesoregion (a subunit of the Western Outer Carpathian Depressions).

The site's hydrological system is primarily represented by the Lower Pond located in the southeastern part of the SCI, serving as the water source for the saline meadow and including a seasonal pool in its centre. The pond is naturally fed by groundwater and precipitation, but also receives effluent from the local wastewater treatment plant (WWTP). Drainage from the pond and the entire salt meadow is channelled via an unnamed stream of approximately 300 m in length running northwest along the southern boundary of the SCI, which subsequently joins another unnamed stream, a right-bank tributary of the Polní Stream (Mikulovka). Both watercourses are classified as water bodies managed by the Morava River Basin Authority. Two concentrated runoff pathways (CRPs) were delineated within the catchment using GIS tools. The longer CRP follows a valley line from the catchment divide in a westerly direction towards the Lower Pond. The second CRP runs north to south across the western part of the site.

4.5.2. Main Ecological Challenges

The principal challenges include maintaining a stable hydrological regime and preventing overgrowth of the salt meadow. Vegetation succession and changes in hydrological conditions lead to habitat degradation and declines in protected species populations. To maintain the halophytic grasslands and their biodiversity, regular management is required, including restoration of traditional grazing, soil disturbance, and mechanical control of invasive species. The water regime has been disrupted by the deepening of the small pond in the southeastern part of the area, channelization and incision of the Polní Stream, deepening of the unnamed outflow stream, and in particular the discharge of wastewater from the municipal WWTP into the pond.

4.5.3. Pollution Source Analysis

The catchment of the site is primarily composed of the built-up area of the municipality. Arable land is present near the catchment divide in the eastern part of the area. According to ZVHS records and confirmed by remote sensing (RS) analysis, there are no constructed agricultural drainage systems in the catchment. The municipality of Dobré Pole has a sewer system serving 395 of its 468 inhabitants. The sewer line runs along the northern edge of the SCI and discharges into a drainage canal. The existing WWTP is located directly on the boundary of the SCI. It is equipped with mechanical-biological treatment technology including nitrification and denitrification, nitrogen removal, and aerobic sludge stabilization. The WWTP was put into operation in 2000 and has a design capacity of 500 population equivalents (PE). Its planned annual discharges include 274 kg of $N\text{-}NH_4$ and 37 kg of total phosphorus. Given the land use and character of the catchment, the primary source of pollution to the SCI waters is municipal wastewater. The most significant source is the WWTP outfall; however, direct runoff from sealed urban surfaces may also contribute. Pollution from agricultural diffuse sources is less likely but may occur through erosion-driven runoff during intense rainfall-runoff episodes (RREs).

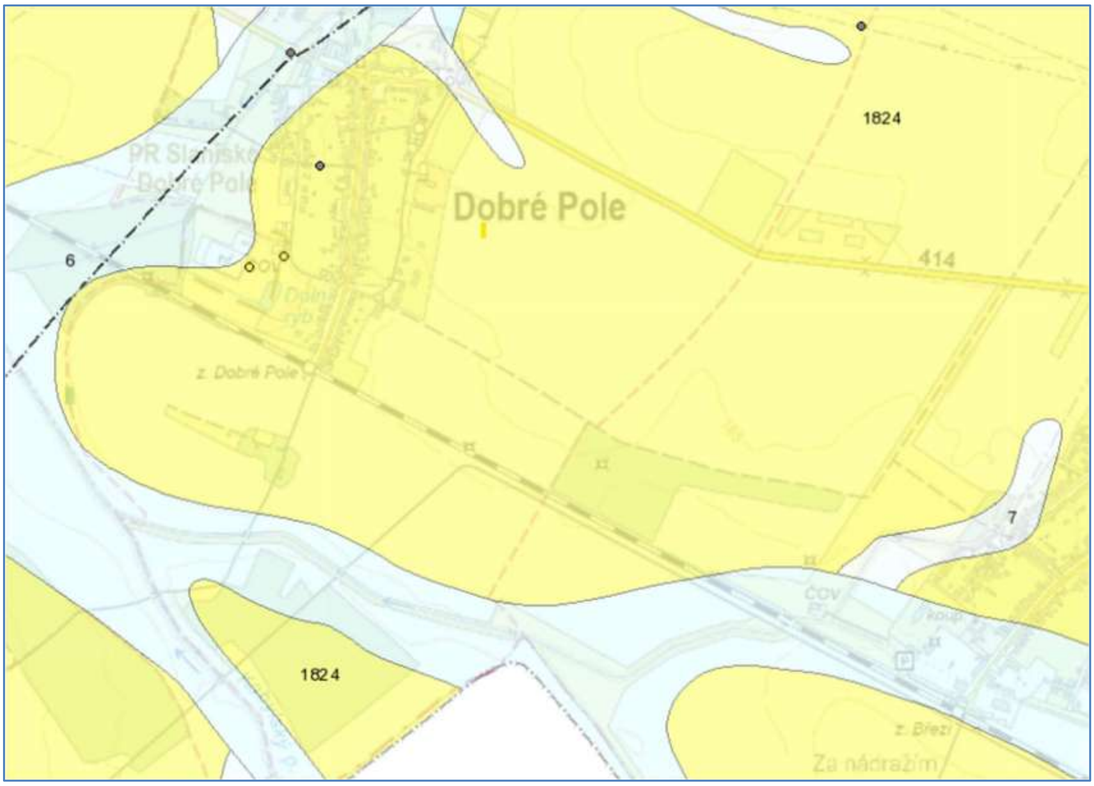

Figure 34: Geological composition of the area of the SCI Dobré Pole (ČGS database): 6 - alluvial sediment, 1824 - calcareous clay (schlieren) with positions of calcareous sands and gravels

Figure 35: Soil cover at the area of SCI Dobré Pole

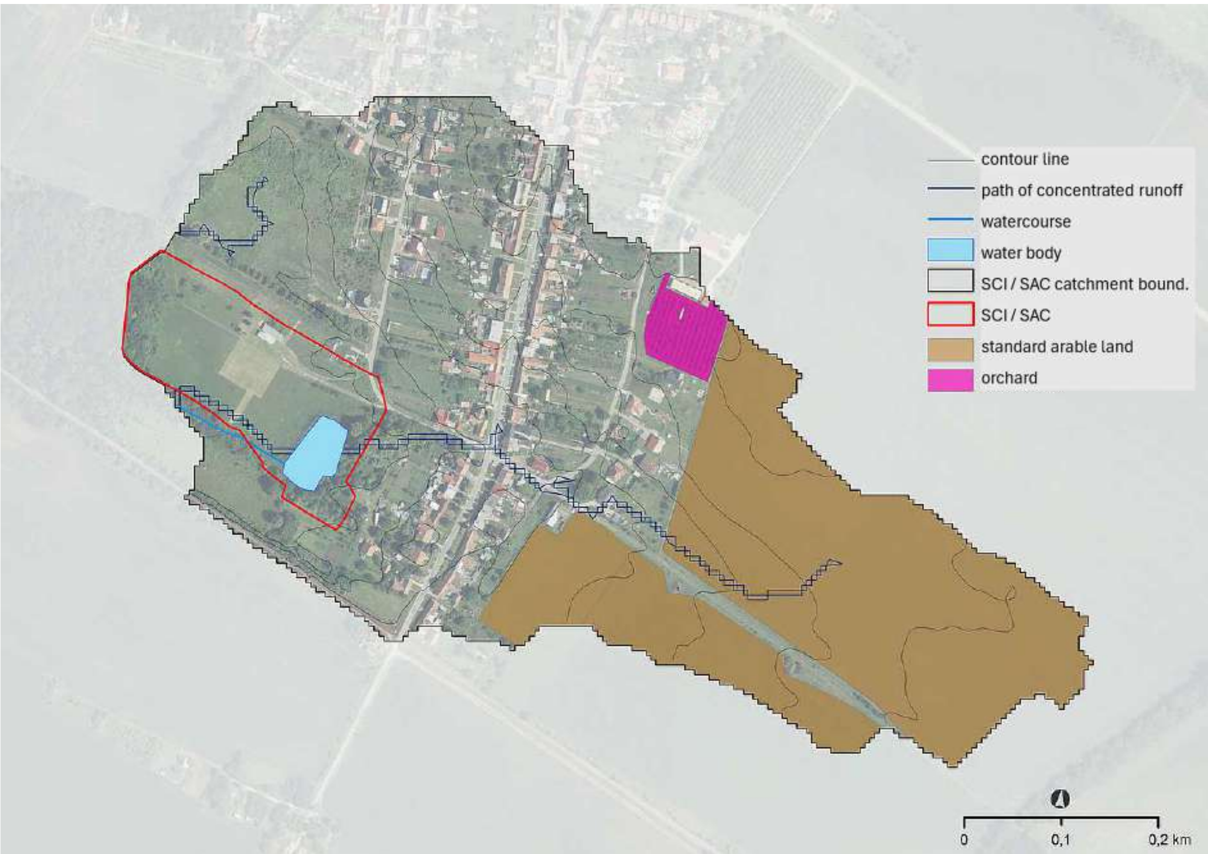

Figure 36: Land use at the SCI Slanisko Dobré Pole

Figure 37: Sources of water pollution in the catchment of SCI Slanisko Dobré Pole

4.5.4. Water Quality in the SCI Dobré Pole

Water quality in the SCI is notably poor, especially during the summer (dry) season. Basic pollution parameters are summarised in Table 10. Extremely high values of conductivity (2076 µS/cm), CODCr (avg. 114.5 mg O_2/l), ammonium, and total phosphorus were detected, corresponding to Class V of surface water quality. NH_4^+ concentrations averaged 8.0 mg/l and total phosphorus 12.53 mg/l—by far the highest recorded values among all monitored sites, exceeding Class V thresholds multiple times. High concentrations of organic carbon (Corg, avg. 19.0 mg/l) were also recorded, corresponding to Class IV. Nitrate (15.1 mg/l) and organic nitrogen (0.9 mg/l) levels were comparatively lower. Salinity indicators were consistent with the site's saline nature, though average among monitored sites—sulfates at 668 mg/l and chlorides at 179 mg/l. Heavy metal concentrations were negligible in winter, but summer values showed elevated zinc (128 µg/l, Class IV) and slightly increased levels of arsenic, cadmium, copper, and nickel (Class II). A water sample for pesticide analysis was taken from the pond at the eastern margin of the SCI (the seasonal pool was dry on 31 July 2024). The results revealed extremely high pesticide concentrations—totaling 40.8 µg/l—dominated by AMPA (28.4 µg/l) and its parent compound glyphosate (11.2 µg/l). Other pesticides totaled 1.23 µg/l, with a predominance of chloracetanilide herbicide metabolites. The extremely high levels of glyphosate and AMPA are likely linked to municipal pollution, given the SCI's location within the village and its proximity to the WWTP. The results indicate major pollution from municipal sources and the effects of decaying biomass in the pond.

Table 10: Average Values of Monitored Water Quality Parameters in the SCI EVL Slanisko Dobré Pole

Parameter / profile	CON (mS/m)	CHSK$_{Cr}$ (mg/l)	Corg (mg/l)	Chlorides (mg/l)	Sulphates (mg/l)	N-NH$_4^+$ (mg/l)	N-NO$_3^-$ (mg/l)	N org. (mg/l)	P$_{tot.}$ (mg/l)	PO$_4$ (mg/l)
Dobré Pole	208	114,48	19,03	179	668	6,22	3,42	0,90	12,53	11,62

(Classification according to Surface water quality classification: ČSN 75 7221–Klasifikace kvality povrchových vod. Úřad pro technickou normalizaci, metrologii a státní zkušebnictví, 2017)

I	Unpolluted water
II	Slightly polluted water
III	Polluted water
IV	Heavily polluted water
V	Severely polluted water

Summary of Water Quality Monitoring

Based on pollution source analysis and monitoring results, the primary water quality risk in this SCI is municipal wastewater input. Extremely high concentrations of ammonium, phosphate, and total phosphorus, as well as pesticides—particularly glyphosate and its metabolite AMPA—were detected, strongly suggesting influence from the WWTP discharge at the site's northern boundary. Agricultural diffuse pollution is unlikely, with potential contributions limited to erosion-driven events from arable land in the eastern catchment during significant rainfall-runoff episodes.

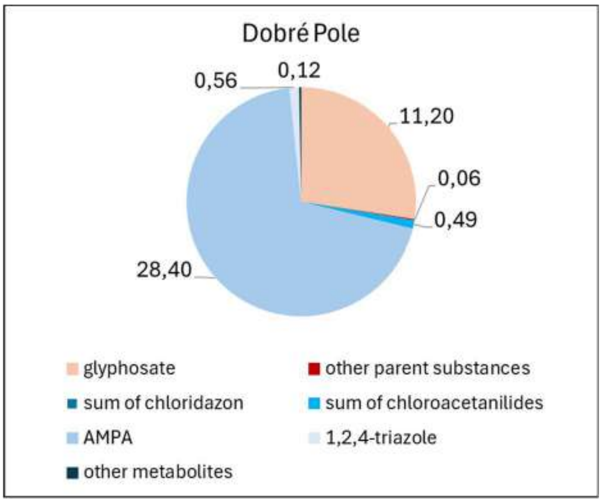

Figure 38: Composition of concentrations of pesticides and their metabolites at the Slanisko Dobré Pole locality

4.5.5. Measures to Stabilize the Water Regime and Improve Water Quality

The fundamental prerequisite for preserving the salt meadow is the elimination of WWTP discharge into the site. This issue is already being addressed, and the outfall will be relocated directly to the stream outside the SCI as part of the WWTP reconstruction. Following this, a key measure is the restoration of the pond (measure DOB 1), involving removal of excess vegetation and sediments, and depth modification as specified in the Initial Management Plan. Sediment deposits from previous pond deepening may be partially used for reshaping the shoreline to create gradual water–land transitions, pending chemical analysis confirming non-toxicity. This intervention concerns plot no. 192, owned by the municipality of Dobré Pole.

Pond restoration will be complemented by measure DOB 2—the revitalization of watercourse IDVT: 10192729 over a length of approx. 205 m. This watercourse drains the pond and the entire SCI. Its desilting and cleaning are required to restore suitable hydrological conditions. If funding allows, channel re-meandering may be considered. These works will enhance watercourse connectivity and reduce runoff velocity. This will be further stabilized by measure DOB 3—accompanying grass seeding along the revitalized channel. These measures affect plots no. 196 (channel) and no. 195, both owned by the municipality.

On the opposite side of the pond, measures DOB 4 and DOB 5 are proposed. DOB 4 involves revitalizing a former watercourse (approx. 95 m), through cleaning and reestablishing a shallow channel to facilitate water inflow to the pond. Measure DOB 5 consists of stabilizing this restored channel with grass cover. Both measures concern plot no. 192, also owned by the municipality. Grass-covered areas must be maintained through regular mowing with biomass removal and reed control.

The final measure, DOB 6, proposes limiting glyphosate use for municipal surface treatment within the cadastral area. Glyphosate spraying can be replaced by alternative herbicides (e.g. Roundup Fast with pelargonic acid) or non-chemical methods such as hot air or steam/hot water treatment. An overview of all proposed measures is shown in Figure 39.

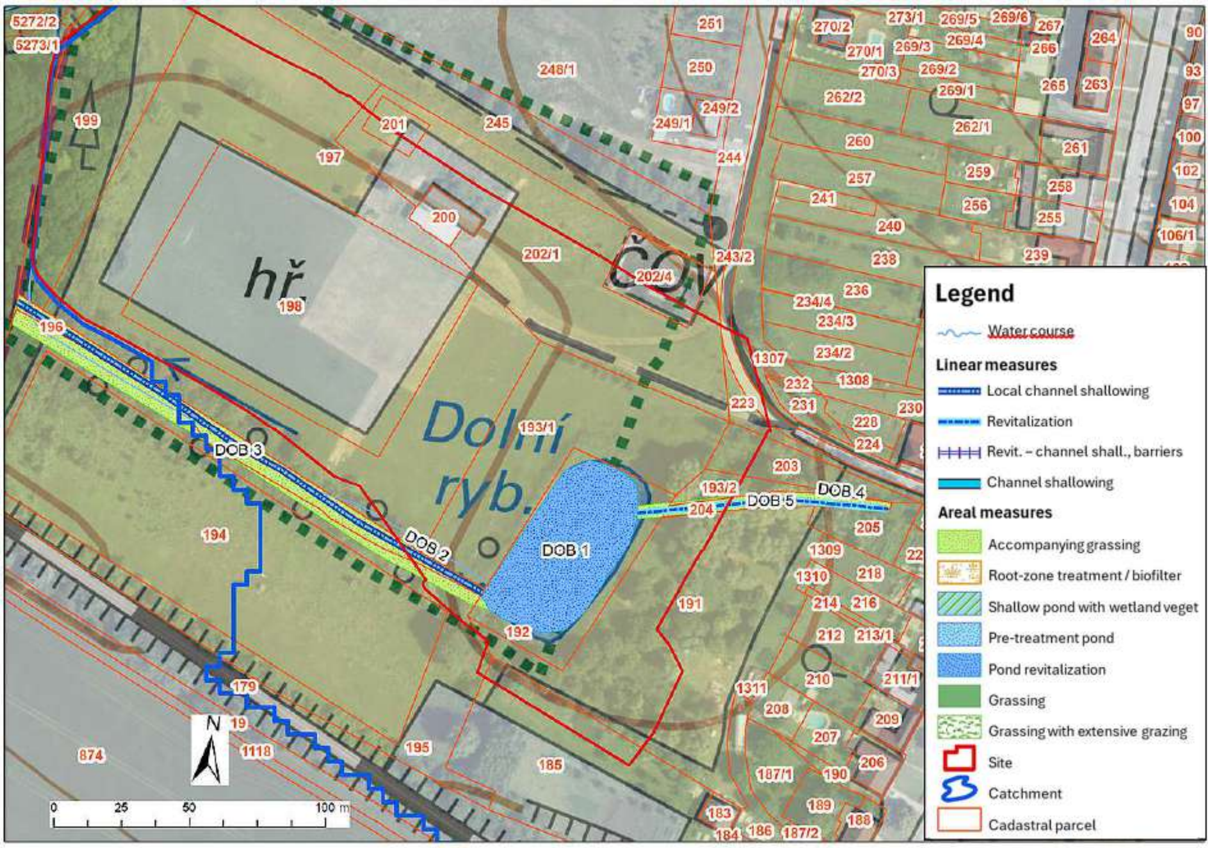

Figure 39: Overview of measures proposed in the Slanisko Dobré Pole SCI catchment area

4.6. HUSÍ PASTVIŠTĚ

The area known as Husí pastviště (Figure 40) forms part of the Věstonická Reservoir National Nature Reserve and the Special Protection Area (SPA) "Střední nádrž vodního díla Nové Mlýny" (CZ0621030). The site is located in the Pannonian biogeographical region, specifically in the South Moravian Region, in close proximity to the Svratka River and its confluence with the Jihlava River. The protection category is national under the designation of a Nature Reserve (PR). The site is particularly significant for the protection of aquatic and wetland habitats and provides critical habitat for both migratory and breeding bird species.

Figure 40: View of the Husí pastviště locality (July 2024)

4.6.1. Site Description and Contributing Area

The area known as Husí pastviště lies on muddy alluvial deposits below the confluence of the Jihlava and Svratka Rivers, at their discharge into the central reservoir of the Nové Mlýny waterworks (Věstonická Reservoir). It comprises a system of primarily man-made pools and islets, periodically inundated and exposed depending on the fluctuating water level in the reservoir.

Geomorphologically, the area falls within the Western Outer Carpathian Depressions subsystem, specifically in the Dyje–Svratka Valley mesoregion, subregion and district Dyjsko-svratecká floodplain. The geological substrate (Figure 41) consists largely of unconsolidated fluviatile sediments and reservoir deposits of varying grain sizes (clay, sand, gravel). In certain locations, organic unconsolidated sediments such as peat, fen, and clay-gyttja deposits occur. The eastern edge of the site is characterized by more coarse-grained fluviatile sediments (sand and gravel). Due to the waterlogged nature of the site, the soil cover has not been described, and thus no soil types have been defined.

Figure 41: Geological map of the Husí pastviště site (ČGS database): 6 – alluvial sediment; 1824 – calcareous clay (schlier) with interbedded calcareous sands and gravels

4.6.2. Main Ecological Challenges

The primary ecological challenges include disruption of the natural water regime and eutrophication caused by nutrient inputs from the entire catchment via the Jihlava and Svratka Rivers. These factors contribute to the degradation of wetland habitats and reduce their capacity to support biodiversity. Another major issue is the spread of invasive species, which disrupt native vegetation and negatively impact the condition of water bodies and wetlands, which are key habitats for target species.

4.6.3. Pollution Source Analysis

Due to the location of the site at the confluence of the Svratka and Jihlava Rivers, no specific catchment area was delineated, as analysing such a large-scale watershed and addressing the input of pollutants would exceed the defined scope and framework of this project. Nevertheless, water quality monitoring was conducted, and the results are presented below.

4.6.4. Water Quality at Husí Pastviště

The pool sampled in this locality is hydrologically connected with the waters of the Svratka and Jihlava Rivers, which together discharge into the central reservoir of the Nové Mlýny waterworks. This connection significantly influences the concentrations of monitored substances. Conductivity values were relatively low, with an average of 604 µS/cm corresponding to Class II water quality. Salinity in this pool was the lowest among all monitored sites, including watercourses—sulfate concentrations averaged 78 mg/l, and chlorides 63 mg/l. Nitrogenous substances were nearly absent in the form of ammonium and nitrates; however, relatively elevated concentrations of organic nitrogen were recorded (averaging 2.8 mg/l), particularly in summer. Phosphorus concentrations were average compared to other monitored sites, with phosphates at 0.42 mg/l and total phosphorus at 0.75 mg/l, corresponding to Class V water quality. Waters in the monitored pool at this site exhibited high values of chemical oxygen demand (CODCr, average 150.5 mg O_2/l – Class V) and organic carbon (Corg, average 18.4 mg/l – Class IV).

During the summer sampling, the site showed elevated concentrations of heavy metals, particularly arsenic (44.9 µg/l), cadmium (2.4 µg/l), zinc (151 µg/l), and lead (26.1 µg/l). All these indicators correspond to Class IV or V water quality. The likely source in this case is exogenous water. Given the scale of the contributing basin, it is not possible to determine the precise source of the pollution load.

The above results from the water quality monitoring at Husí pastviště do not indicate significant external pollution inputs unless an accidental contamination event occurs on the Svratka or

Jihlava Rivers. Elevated levels of organic carbon and high COD suggest endogenous pollution from the decomposition of accumulated biomass within the pool itself.

Table 11: Average Values of Monitored Water Quality Parameters at the Husí pastviště Site

Parameter / profile	CON (mS/m)	$CHSK_{Cr}$ (mg/l)	Corg (mg/l)	Chlorides (mg/l)	Sulphates (mg/l)	$N\text{-}NH_4^+$ (mg/l)	$N\text{-}NO_3^-$ (mg/l)	N org. (mg/l)	$P_{tot.}$ (mg/l)	PO_4 (mg/l)
Husí pastviště	60	150,56	18,40	63	78	0,03	0,33	2,78	0,75	0,42

(Classification according to Surface water quality classification: ČSN 75 7221–Klasifikace kvality povrchových vod. Úřad pro technickou normalizaci, metrologii a státní zkušebnictví, 2017)

I	Unpolluted water
II	Slightly polluted water
III	Polluted water
IV	Heavily polluted water
V	Severely polluted water

4.6.5. Measures to Stabilize the Water Regime and Improve Water Quality

The implementation of biotechnical measures to reduce pollution inputs into the site is not feasible due to the nature of the locality, the discharge volumes of both rivers, and the size of the contributing area. Addressing water quality at this scale must be carried out at regional or national levels, for example, through the implementation of the EU Water Framework Directive. At the local scale, it is possible to address water pollution in pools by removing excess biomass, e.g., through grazing.

4.7. SAC TRKMANEC RYBNÍČKY

The Trkmanec–Rybníčky site (Fig. 42) is part of the Natura 2000 network as a Special Area of Conservation (SAC) under code CZ0622037, covering an area of 44.3319 ha. It is located in the flat floodplain at the confluence of the Trkmanka River and the Bílovický potok, within the Břeclav District, South Moravian Region. The site is nationally protected as a Nature Monument (PP). It is significant for its vegetation of the Phragmito-Magno-Caricetea type, particularly continental brackish reed beds (Meliloto dentati–Bolboschoenion maritimi) and other halophytic communities. The site is also notable for the occurrence of the rare thistle species Cirsium brachycephalum.

Figure 42: View of the SAC Trkmanec Rybníčky (October 2024)

4.7.1. Site Description and Contributing Catchment

The Trkmanec SCI, with an area of 44.3 ha, has a relatively large catchment of 1,689.6 ha. The geological composition is rather diverse (Fig. 43). A substantial portion of the SCI consists of unconsolidated anthropogenic fill. In the northern part, unconsolidated calcareous clays (Bílovice Formation, Vienna Basin – Moravian part, Miocene age) are predominant. The western and southern parts are characterized by unconsolidated fluvial (alluvial) Quaternary sediments (clay, sand, gravel). Similar geological formations are found in the catchment, with Pleistocene loess and loess loam (composed of quartz, admixtures, and $CaCO_3$) occurring near the watershed divide. Geomorphologically, most of the catchment belongs to the Western Carpathians province, while the SCI itself lies within the Western Pannonian Basin, specifically the Trkmanec floodplain district, part of the Dyje–Morava Upland subunit and the Lower Morava Valley unit. In terms of soil cover (Fig. 44), due to anthropogenic fill and wet areas, soil types were not specified in most of the SCI, except for the eastern part where chernozems were identified. Chernozems also dominate the catchment, with gleysols along the Trkmanka stream. These are mostly deep, non-skeletal (sometimes slightly skeletal) soils with moderate infiltration rates (0.06–0.12 mm/min). Soils in the SCI have medium water retention capacity, while soils in the catchment have very high retention capacity.

The site lies in the catchment of the Trkmanka River, near its confluence with its left tributary, the Bílovice Stream. Naturally, the catchment drains into the Trkmanka, primarily through the Bílovice Stream and its tributaries. On the right tributary of the Bílovice Stream, Šísárek, there is a water body named Šísary. The Bílovice Stream directly interacts with the SCI through bank filtration and a network of drainage channels. At the southern edge of the SCI, the stream flows into the Trkmanka, with the confluence regulated by a sluice gate. Although the Trkmanka (average annual discharge at Velké Pavlovice station: 0.33 m^3/s) is separated from the SCI by a high levee, seasonal flow variations influence groundwater levels and the extent of pools in the western part of the SCI. The hydrological situation is relatively complex due to extensive land drainage interventions.

4.7.2. Main Ecological Challenges of SAC Trkmanec–Rybníčky

The main ecological challenges include disruption of the natural water regime due to historical regulatory interventions and increasing occurrence of invasive species. Habitat degradation caused by drainage and eutrophication is leading to the decline of valuable biotopes, particularly halophytic vegetation. To maintain and restore the ecosystem, implementation of regular management is essential, including periodic disturbance of habitats and restoration of the hydrological regime.

4.7.3. Analysis of Water Pollution Sources in SAC Trkmanec–Rybníčky

According to current LPIS data, the catchment is intensively used for agriculture, with farmland covering 69.1% of the catchment area. Arable land accounts for 43.9% of the catchment, forming a significant share of the agricultural land. Land use in the SAC is shown in Fig. 45. Due to intensive agricultural use, fertile soils, and topography, both the catchment and the SAC have undergone many water management modifications (land drainage). In the past, irrigation and drainage systems were constructed, and extensive regulatory drainage with an irrigation function was planned within the SAC itself. Currently, according to the ZVHS database, 494.4 ha of agricultural drainage systems are recorded in the catchment. Drainage is also recorded in the northwestern part of the SAC. Remote sensing confirmed the location of some drainage infrastructure. The area is interwoven with a dense network of drainage channels, three of which enter the SAC, including a central channel and another along the western edge.

Point sources of pollution include municipal wastewater from the town of Velké Bílovice (population 3,883). The sewer system is combined and includes approximately six storm overflow chambers, which discharge diluted wastewater during heavy rainfall events. The WWTP Velké Bílovice discharges into the Bílovice Stream and has been recently upgraded with submerged membrane bioreactors designed to remove most suspended solids, microorganisms, and viruses. The current planned discharge limits are 271 kg/year for ammonium nitrogen ($N–NH_4$) and 349 kg/year for total phosphorus. According to the PRVK JMK plan, a new WWTP and outlet were proposed for the northern edge of the SAC near Trkmanský Dvůr. However, the 2022 update of the Rakvice municipal zoning plan abandoned this plan, and wastewater treatment for Trkmanský Dvůr will be handled locally. An overview of possible pollution sources is shown in Fig. 46.

Based on this analysis, the water quality in SCI Trkmanec–Rybníčky is likely threatened by both diffuse agricultural sources (especially drained agricultural land near the Bílovice Stream) and point sources (WWTP outlet at Velké Bílovice), bringing municipal pollution.

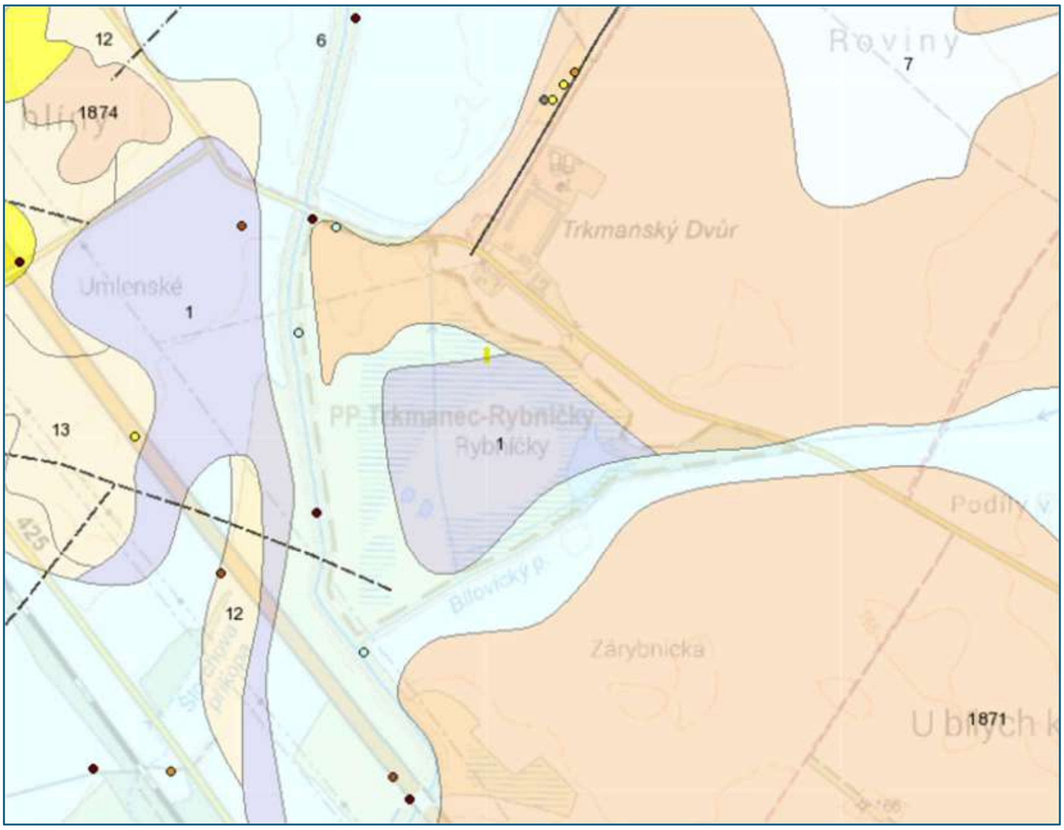

Figure 43: Geological background of the area of the Trkmanec-Rybníčky SAC (ČGS database); 1 - spoil (spoil), 6 - alluvial sediment, 7 - mixed sediment, 12 - sandy-clay to clayey-sandy sediment, 13 - stony to clayey-stony sediment, 1871 - calcareous clays, clays, sands, organodetritic limestones and sandstones, sandy limestones

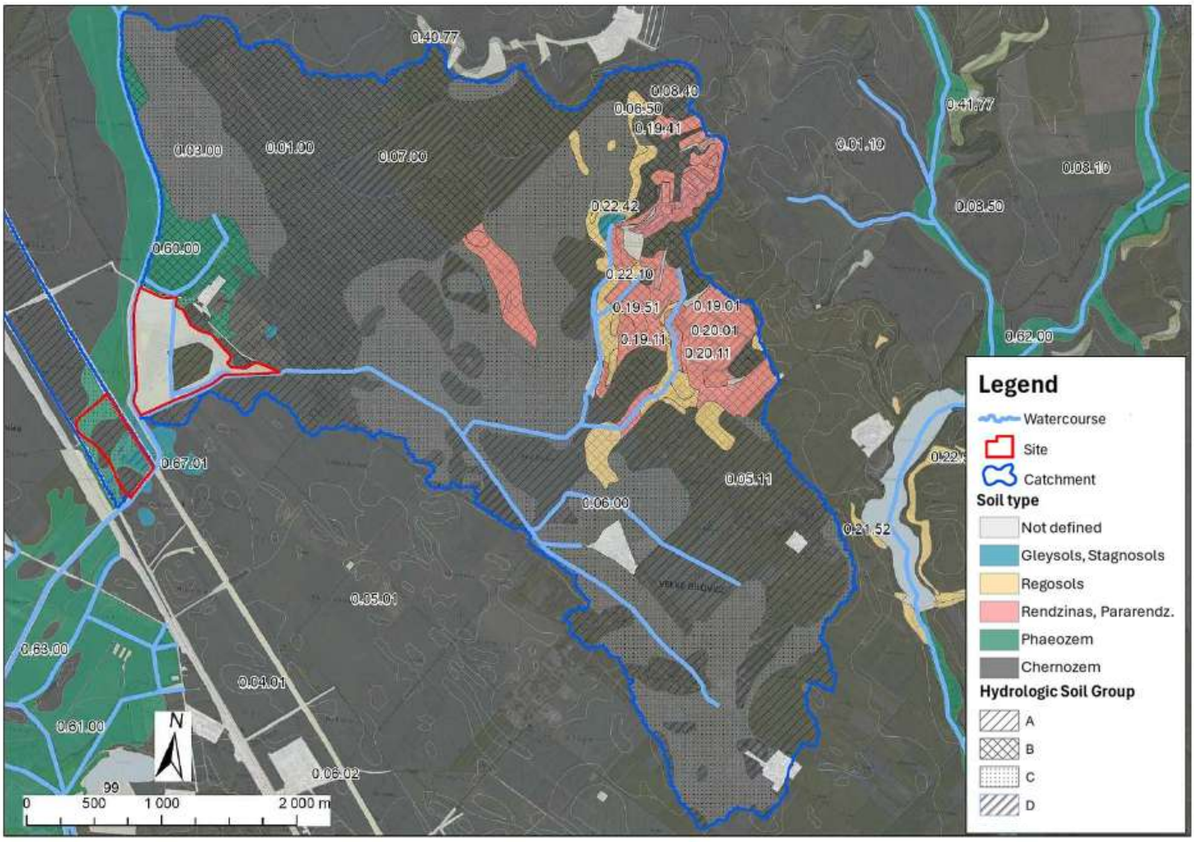

Figure 44: Soil cover at SAC Trkmanec-Rybníčky

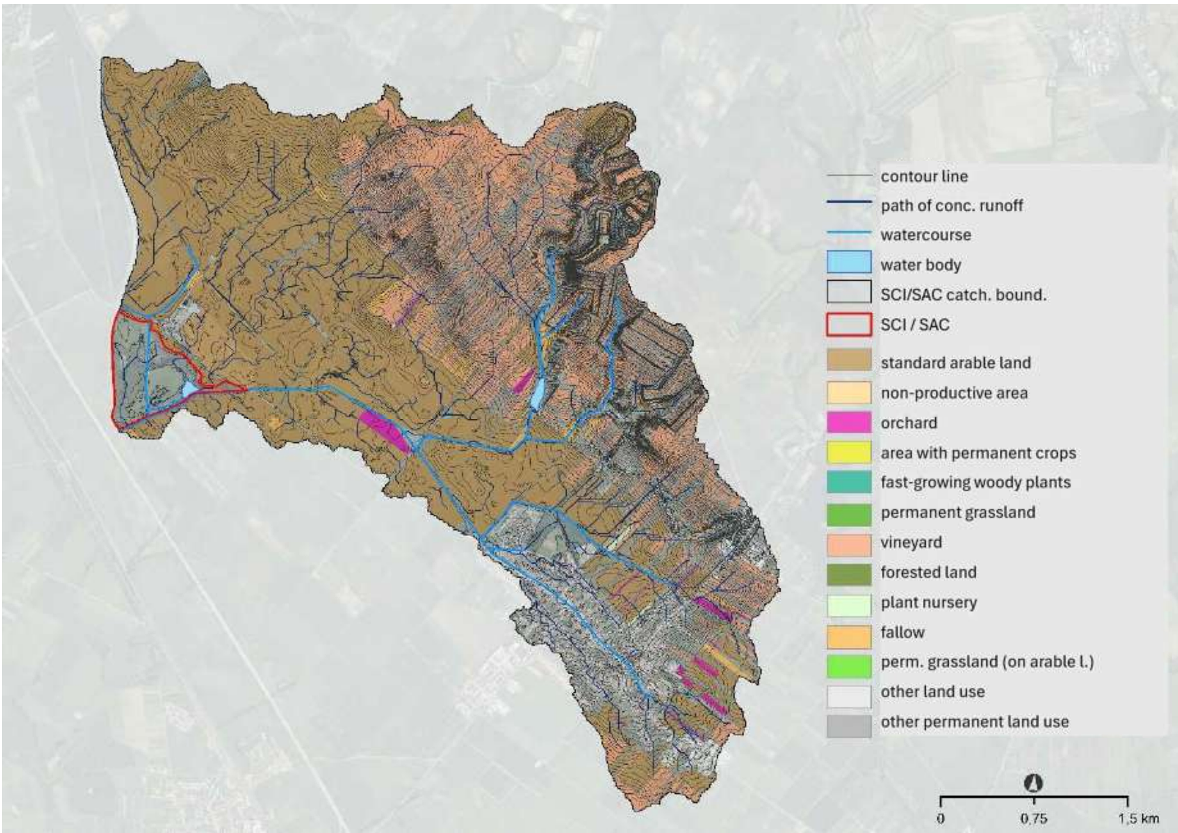

Figure 45: Land use in the SAC Trkmanec-Rybníčky catchment

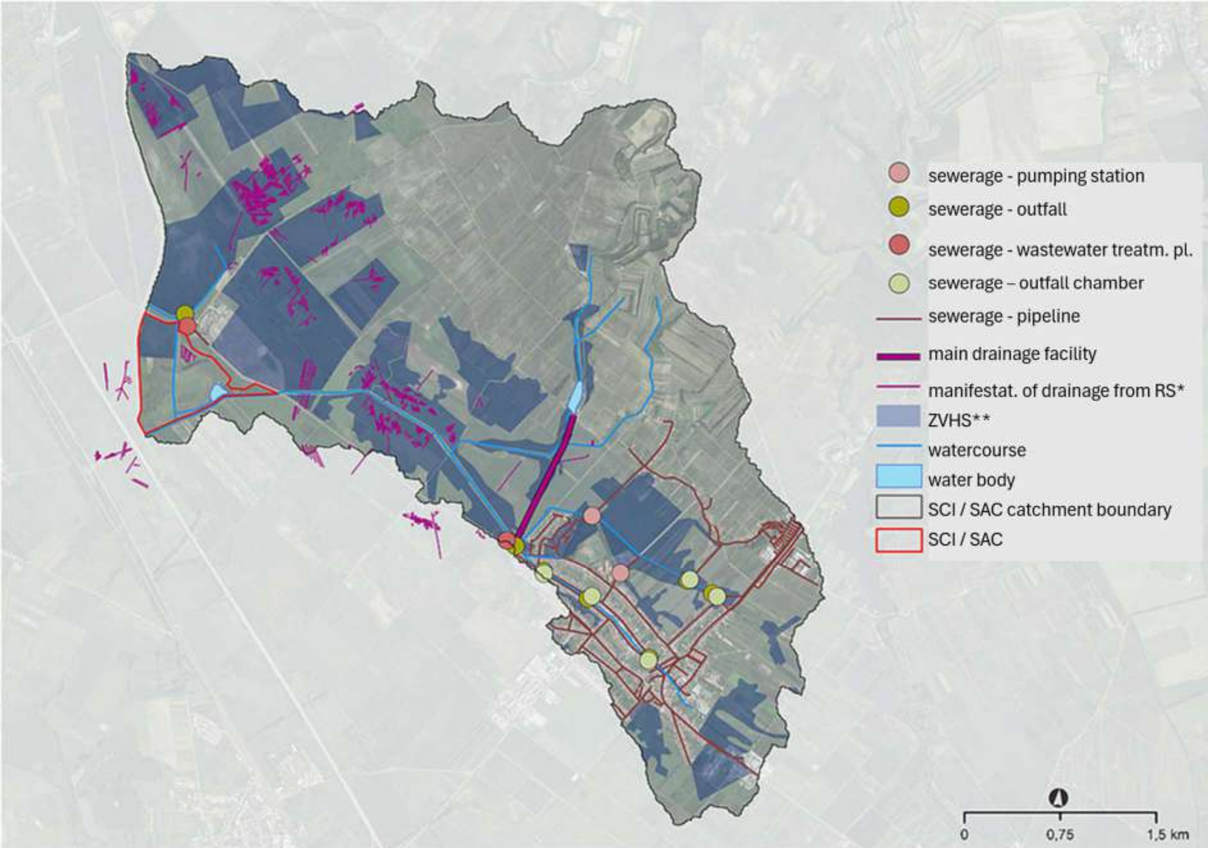

Figure 46: Sources of water pollution at SAC Trkmanec-Rybníčky catchment
**RS – Remote Sensing; **Former Agricultural Water Management Administration (in Czech ZVHS)*

4.7.4. Water Quality in the SAC Trkmanec–Rybníčky

The area of interest lies between two watercourses and is interwoven with a network of drainage and irrigation channels. Several pools are also present within the site, some of which are directly connected to one of the streams. For the assessment of water quality in this SCI, the Bílovický Stream was selected as a representative profile due to its direct influence on water quantity and quality in the locality. In addition, two pools were monitored: the "Large Pool," directly connected to the stream, and the "Small Pool," situated near the center of the monitored area. Several water samples were also taken from the central channel along its northern boundary.

<u>Bílovický potok (stream)</u>

The water in the Bílovický potok was heavily loaded with various pollutants. Very high conductivity values (2,220 µS/cm, quality class V) indicated a large concentration of dissolved ions, including sulfates (average 513 mg/l), chlorides (average 134 mg/l), and both forms of phosphorus. The average phosphate concentration was 1.86 mg/l, and total phosphorus reached 2.1 mg/l (both quality class V). Ammonium nitrogen was also relatively elevated (1.07 mg/l, class IV), while nitrate concentrations remained low (average 8.2 mg/l), even considering the agricultural character of the catchment. High values of chemical oxygen demand (CHSK_Cr 110.3 mgO_2/l, class V) were detected, despite the fact that this is a flowing water body rather than a stagnant pool. Organic carbon concentrations (C_org 11.0 mg/l) corresponded to quality class III.

A broad spectrum of 41 pesticides and their metabolites was detected in the waters of the Bílovický potok. From the perspective of pesticide concentrations, the stream was significantly burdened, particularly by glyphosate and its main metabolite AMPA. Total concentrations ranged from 3.3 µg/l in winter to 12.0 µg/l at the end of July 2024. Glyphosate and AMPA together accounted for approximately 74% of the total concentration, with peak levels reaching 3.9 µg/l for glyphosate and 5.42 µg/l for AMPA. The persistent presence of these substances, combined with the presence of a wastewater treatment plant (WWTP) in the catchment, suggests municipal sources as the likely origin. The concentrations of other compounds reflected significant agricultural use of the catchment area, although they were not considerably higher compared to other monitored streams. The highest concentrations were observed for chloridazon metabolites (average 0.69 µg/l) and 1,2,4-triazole (average 0.23 µg/l). Parent compounds were primarily present during the summer, including metalaxyl, spiroxamine, fenhexamid, tebuconazole, and boscalid, in low tenths of µg/l.

Velká tůň

This sampling profile is located in close proximity to the Bílovický potok and exhibited similar analytical results: high values of CHSK_Cr (66.3 mg/l, class V), conductivity (2,378 µS/cm, class V), total phosphorus (2.08 mg/l, class V), sulfates (758 mg/l, class V), and organic carbon (C_org 20.66 mg/l, class V). Only ammonium ion concentrations (average 0.89 mg/l) were somewhat lower, corresponding to class III. Salinity was slightly higher than in the stream, with average sulfate concentrations of 758 mg/l and chloride concentrations of 166 mg/l.

Samples for pesticide analysis were taken from this pool during two campaigns in the summer (20 and 30 July 2024). In both samples, pesticide substances were detected in total concentrations of 0.76 µg/l and 0.61 µg/l, respectively. The composition was dominated by metabolites, particularly metolachlor ESA and chloridazon metabolites. AMPA and its parent compound glyphosate were also present at lower levels. The low concentrations of pesticide substances may indicate either limited hydrological connectivity between the pool and the stream or a high capacity of wetland vegetation to bind and degrade these substances.

Střední stoka

Results from the central channel sampling profile were classified identically to those from the Velká tůň. However, some indicator values were even higher, as documented in Table 12.

Malá tůň

At this profile, extremely high conductivity values were recorded (average 5,352 µS/cm), corresponding to the highest salinity among all monitored sites. The average sulfate concentration was 2,808 mg/l, and chlorides reached 363 mg/l. Significant organic pollution was also observed, indicated by a high average CHSK_Cr value (157 mgO_2/l, class V) and a high concentration of organic carbon (C_org 35.5 mg/l, class V). Organic nitrogen was also higher, with an average value of 2.49 mg/l. Conversely, ammonium and nitrate nitrogen concentrations were low and classified as class I. Both monitored forms of phosphorus were also found in low concentrations.

Screening monitoring also detected pesticide substances in this pool. However, their total concentration was relatively low (0.32 µg/l). Fourteen substances were identified, with a slight predominance of metabolites (56% of the total concentration). The concentrations of individual substances ranged from single to tens of nanograms. Among parent compounds, dinoterb was most frequent; among metabolites, alachlor OA and metolachlor ESA were prevalent. The presence of alachlor metabolite indicates legacy pollution, as this substance has been banned since 2013.

Summary of water quality monitoring results

The water quality in the Trkmanec - Rybníčky SAC is threatened by both agricultural sources of pollution (especially drained agricultural land in the vicinity of the Bílovický Brook) and point sources (sewage discharge from the Velké Bílovice WWTP) bringing municipal pollution. The main tributary of water to this EVL is the Bílovický potok, which is heavily polluted mainly by both forms of phosphorus and ammonium ions. High concentrations have also been detected for pesticides, in particular glyphosate and its metabolite AMPA, however a range of 44 different substances have been detected in the stream waters. In the monitored pools, pollution decreases with increasing distance from the Bílovický potok. "The 'large pond', which is directly connected to the stream, is similarly polluted to the stream, except for lower concentrations of ammonium ions. On the other hand, there is pollution from dead biomass characterised by high concentrations of organic carbon. In the so-called “Malá tůň, which is closer to the centre of the site of interest, there is no longer any external nutrient or pesticide loading, but the very high organic carbon concentrations indicate a significant dead biomass content in this pool.

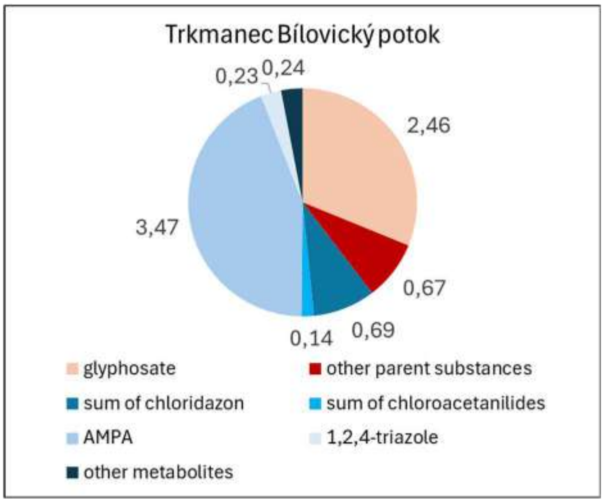

Figure 47: Composition of pesticide substances in the waters of the Bílovický potok (SAC Trkmanec-Rybníčky)

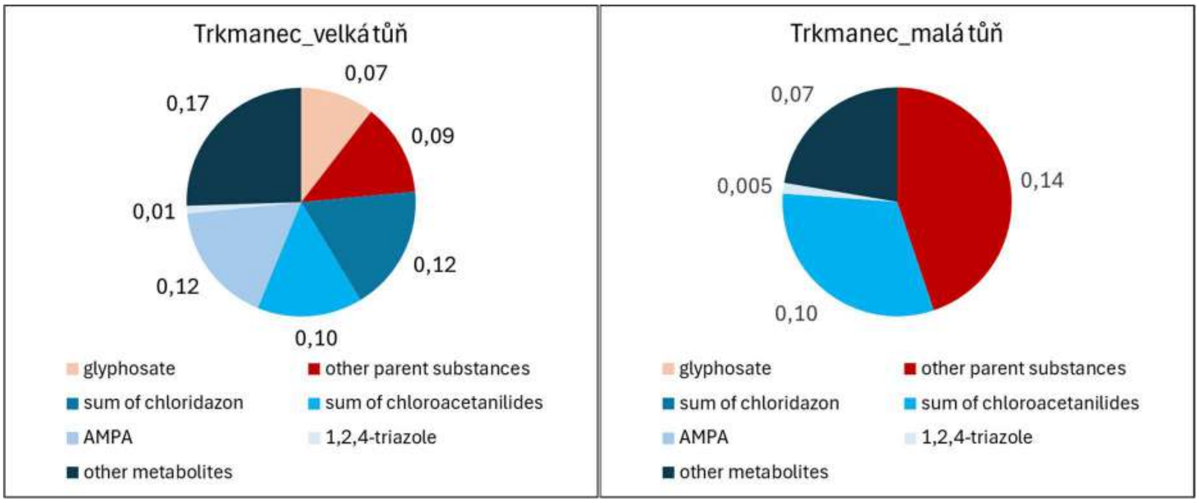

Figure 48: Composition of pesticide substances in the waters of the monitored pools in the SAC Trkmanec-Rybníčky

Table 12: Average values of monitored water chemical indicators at SAC Trkmanec-Rybníčky

(Classification according to Surface water quality classification: ČSN 75 7221–Klasifikace kvality povrchových vod. Úřad pro technickou normalizaci, metrologii a státní zkušebnictví, 2017)

Parameter / profile	CON (mS/m)	CHSK$_{Cr}$ (mg/l)	Corg (mg/l)	Chlorides (mg/l)	Sulphates (mg/l)	N-NH_4^+ (mg/l)	N-NO_3^- (mg/l)	N org. (mg/l)	$P_{tot.}$ (mg/l)	PO_4 (mg/l)
Bílovický potok	221	110,26	11,00	134	513	1,07	1,86	1,59	2,10	1,86
Trkmanec malá tůň	535	157,00	35,52	363	2 808	0,06	0,33	2,49	0,22	0,05
střední stoka	313	143,12	20,10	162	1 151	0,69	0,80	1,81	1,45	1,26
Trkmanec velká tůň	238	66,30	20,66	166	758	0,69	0,87	2,56	2,08	1,83

I	Unpolluted water
II	Slightly polluted water
III	Polluted water
IV	Heavily polluted water
V	Severely polluted water

4.7.5. Measures for Stabilising the Water Regime and Improving Water Quality in SAC Trkmanec–Rybníčky

The primary objective of all proposed measures within the SAC Trkmanec–Rybníčky must be to prevent the inflow of pollution from the Bílovický potok into the salt meadow habitat. This objective is addressed by measure TRK 1 (Fig. 49). The optimal solution would be the revitalisation of the stream channel, at least in the section between the road Velké Bílovice – Velké Pavlovice. The key interventions include channel shallowing, desilting, and removal of excess biomass. Through shallowing of the bed and possible modifications of channel slope, the self-purification capacity of the watercourse can be enhanced, surface runoff slowed, and the natural connection between the stream and its surroundings restored. As an alternative, the installation of several check dams is possible. However, this variant would require maintenance (due to soil conditions), specifically cleaning every 2–3 years. The stream lies on parcel no. 5417, which is owned by the Czech Republic and managed by the state enterprise Povodí Moravy. The land in the lower section of the stream is relatively wide (20–25 m), making it suitable for revitalisation interventions.

Measures TRK 2 and TRK 3 represent two biofilters designed to eliminate pollutants from the Bílovický potok. Biofilter TRK 2 can be constructed as a lateral system with a bypass, situated between the Bílovický potok and the central channel, allowing pre-treated water to be redirected into the SCI area. Biofilter TRK 3 would ideally be built as an in-stream constructed wetland following the channel's re-profiling; however, this solution will likely not be accepted by Povodí Moravy, s.p., the administrator of parcel no. 5417, or by surrounding private landowners. As an alternative, an open or closed lateral biofilter may be installed. For both proposed biofilters, a substrate composed of wood chips supplemented with biochar is recommended due to its effectiveness in reducing pesticide concentrations.

Measure TRK 4 entails the shallowing (partial infilling) of the central channel over a length of 780 m. Decreasing the depth of the channel will improve hydrological connectivity with the surrounding environment while maintaining the ability to drain surplus water from storm events or snowmelt.

Measures TRK 5 and TRK 6 propose the conversion of arable land into grassland managed through extensive grazing. Along the northeastern margin of the SCI, between its boundary and road no. III/42113, two arable land blocks (parcels 4902/1 and 4802/1), each with an area of 2.2 hectares, are located. These parcels lie within the SCI's buffer zone. Arable land is a potential source of excess nutrients and pesticide residues affecting the water quality in the area, and should thus be converted into permanent grassland, preferably managed through extensive grazing. Regarding land ownership, most of the measure would affect parcel no. 5308/1, which is owned by the municipality. A portion of the block also extends into parcels 3203/5–11, also owned by the municipality of Rakvice, and into parcels 5308/3,4,5, which are privately owned.

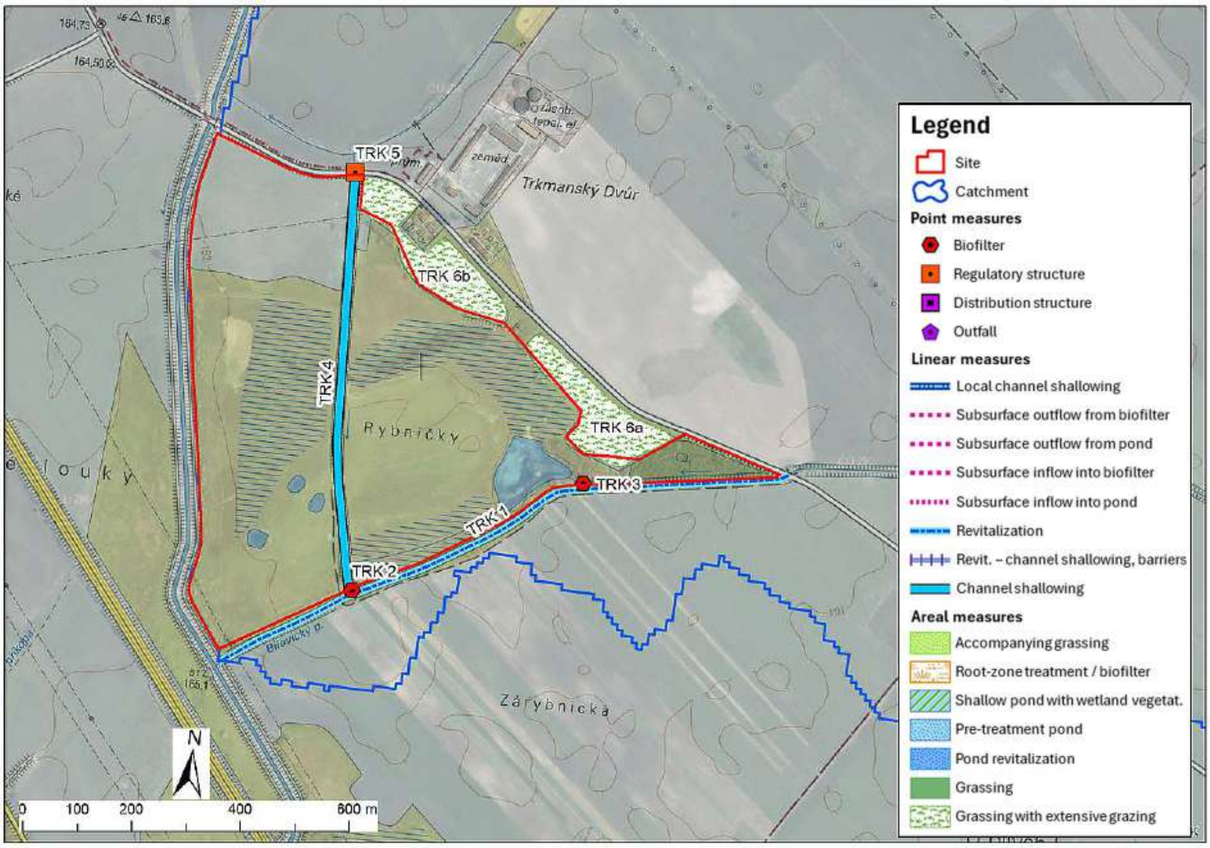

Figure 49: Overview of measures proposed in the SAC Trkmanec-Rybníčky catchment area

4.8. SAC TRKMANSKÉ LOUKY

Trkmanské louky (Fig. 50) represent a Site of Community Importance (SCI) under the NATURA 2000 network, designated as CZ0622026, with a total area of 19.0259 ha. The site is located in the Pannonian biogeographical region, within the Břeclav District of the South Moravian Region. Although it is not currently declared as a specially protected area, its legal designation is under preparation. The site provides critical habitat for numerous rare and endangered species of flora and fauna, including the critically endangered Cirsium brachycephalum.

Figure 50. SAC Trkmanské louky, October 2024.

4.8.1. Site Description and Contributing Area

The area is situated approximately 1.7 km east of the municipality of Rakvice, within the floodplain of the Trkmanka River at an elevation of approximately 162 m a.s.l. The terrain is flat, featuring numerous shallow depressions that are episodically, periodically, or permanently waterlogged.

Geomorphologically, the site belongs to the Lower Morava Basin and represents an accumulation plain along the Trkmanka River. It is located within a warm climatic zone characterised by a very long, dry, and hot summer season. From a phytogeographical perspective, the area belongs to the thermophyticum region, specifically the Dyje–Svratka Basin sub-district (18a).

The geological substratum (Fig. 51) consists of rocks from the Flysch Belt, overlain by unconsolidated alluvial sediments (clay, sand, gravel), deluvial sediments (sandy loam to loamy sand), and stony to loamy-stony deposits. A portion of the area is affected by anthropogenic fill.

The soil cover (Fig. 52) is primarily composed of chernic soils and chernozems, with gley soils present along the eastern boundary of the site. From a hydropedological perspective, chernic soils belong to hydrological group C (soils with low infiltration rates, 0.02–0.06 mm/min, typically with a low-permeability horizon and a clay loam to clay texture), chernozems to group A (soils with high hydraulic conductivity), and gley soils to group D (soils with very low saturated hydraulic conductivity).

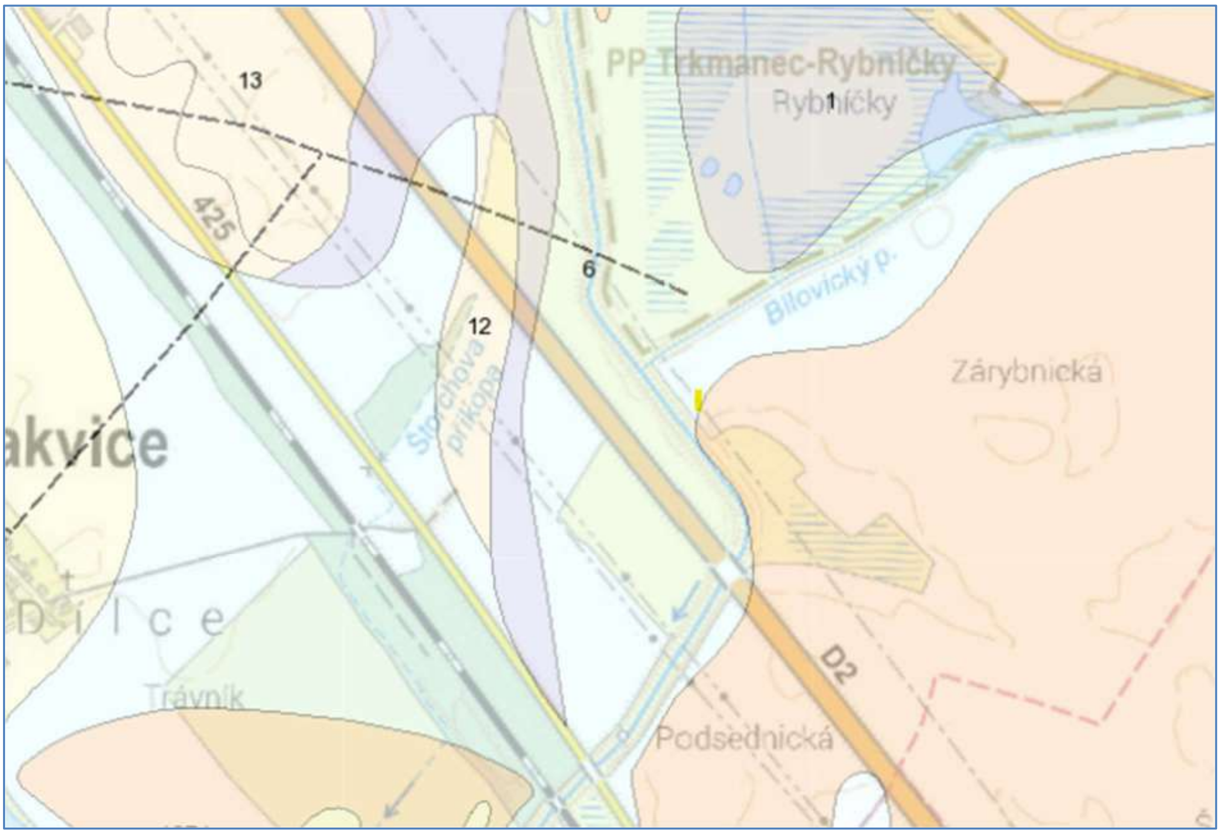

Figure 51: Geological substratum of SAC Trkmanské louky (ČGS database); 1 – anthropogenic fill (spoil), 6 – alluvial sediment (clay, sand, gravel), 12 – sandy-loam to loamy-sand sediment, 13 – stony to loamy-stony sediment

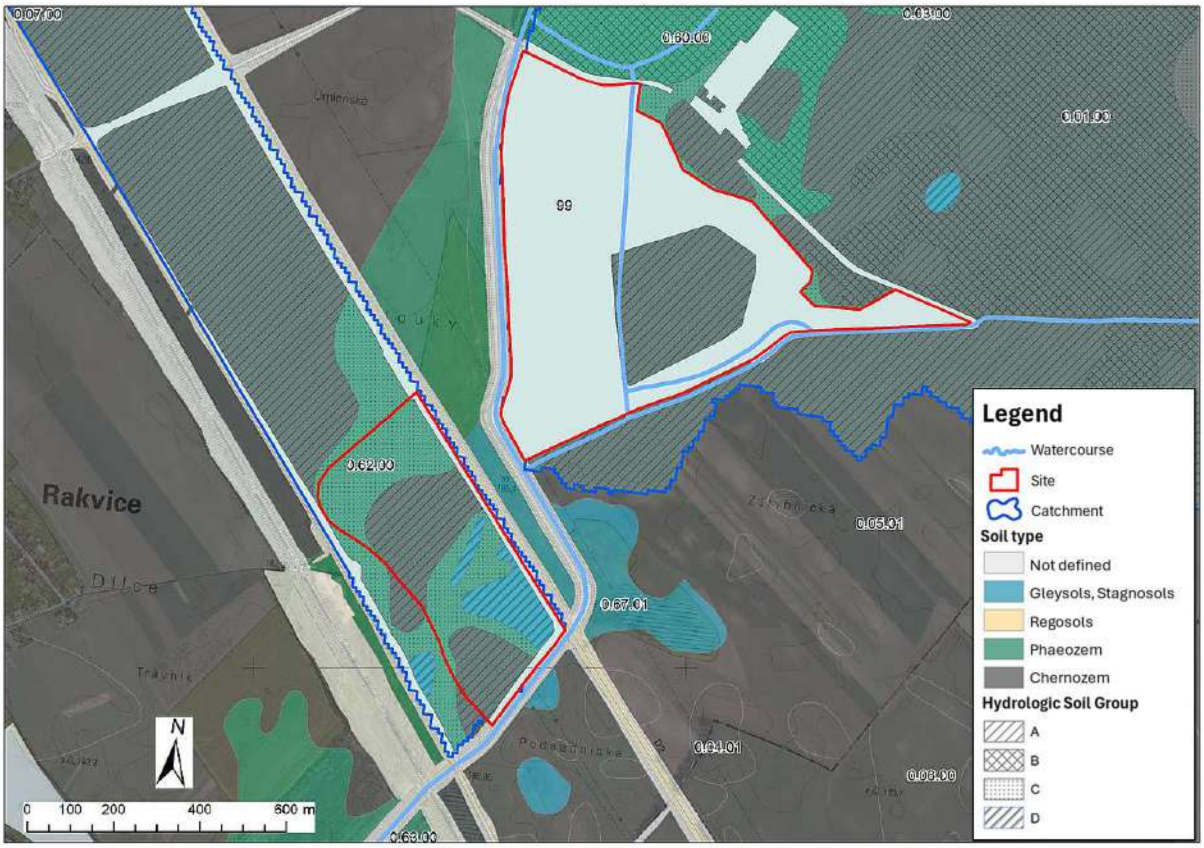

Figure 52: Soil cover of SAC Trkmanské louky

4.8.2. Main Ecological Challenges of SAC Trkmanské louky

The principal ecological challenge in SAC Trkmanské louky is the preservation of the water regime and the control of sedimentation in water bodies. Alterations in hydrology and long-term drought threaten halophilous habitats, leading to the gradual disappearance of suitable microhabitats for Cirsium brachycephalum and other protected species. In addition, dense reed stands must be periodically disturbed, as they degrade conditions for competitively weaker plant species. The expansion of invasive and expansive species in waterlogged zones also requires active management.

4.8.3. Analysis of Pollution Sources Affecting SAC Trkmanské louky

SCI Trkmanské louky covers an area of 19.0 ha, with a contributing catchment area of 183.6 ha. Most of the catchment is agriculturally utilised (81.4%), almost exclusively as arable land (Fig. 53). According to the ZVHS database, 58.0 ha of agricultural drainage systems are present within the catchment (Fig. 54). Remote sensing data (DPZ) confirmed the presence of drainage structures both within the catchment and within the SCI itself. Subsurface drainage systems extend southeastward through the catchment and discharge into the Trkmanka River. The catchment contains no sewerage network or wastewater treatment plant. Pollution of surface waters is likely to originate from diffuse agricultural sources, primarily through drainage outflow. Most of the SCI area is currently managed for agriculture. The extent of agrotechnical operations depends on the current groundwater level, which influences the accessibility of the land to agricultural machinery.

4.8.4. Water quality in SAC Trkmanské louky

During the field survey, no active inflow was identified in this locality. Therefore, water quality was not assessed.

4.8.5. Measures for Stabilising the Water Regime and Improving Water Quality in SAC Trkmanské louky

No biotechnical measures have been proposed for the site. From the perspective of mitigating pollution, including water contamination, it is recommended to implement protective management on agricultural land within the SCI, including the minimisation of pesticide inputs. If there is a need to improve the site's water regime in response to ongoing climate change (particularly increased evapotranspiration), a detailed investigation and potential decommissioning of agricultural drainage systems should be considered. However, implementation of such measures is fully dependent on the willingness and cooperation of landowners and land users.

Figure 53: Land use in the SAC Trkmanské louky catchment

Figure 54: Sources of water pollution in the catchment of SAC Trkmanské louky
**RS – Remote Sensing; **Former Agricultural Water Management Administration (in Czech ZVHS)*

4.9. SAC Hodonínská doubrava – locality Ptačí park Kosteliska

The Kosteliska site (Fig. 55) is part of the Hodonínská Doubrava Special Area of Conservation (SAC) under the NATURA 2000 network, with the site code CZ0624070 and a total area of 3,029.0835 ha. The Kosteliska subsite, situated in the northern part of Hodonínská Doubrava within the floodplain of the Kyjovka River, is primarily important for the protection of wetland habitats, sand dunes, and surrounding forest ecosystems. The site hosts sandy oak forests, wetlands, and meadow ecosystems that provide critical habitats for rare plant and animal species.

Figure 55. View of the Kosteliska site, June 2024

4.9.1. Site Description and Contributing Area

Bird Park Kosteliska is a private non-governmental reserve focused on the conservation of birds and their habitats and is part of the Hodonínská Doubrava SCI. It is located in the floodplain of the Kyjovka River, north of Jarohněvický rybník (Pond), within the cadastral territories of Dubňany and partly Hovorany, in the Hodonín District. The park's name is derived from a meadow in its northeastern corner. The area consists of a mosaic of water bodies, reed beds, meadows, shrubs, and groves. In the 19th century, much of the area was part of a large pond, which gradually silted up, leading to the expansion of wet and waterlogged meadows.

Geologically (Fig. 56), the site is underlain by river terrace gravels and sands, overlain by wind-blown sands of variable thickness. Loess and loess loam occur to the west, and clays and silty clays dominate the eastern portion. The soil cover (Fig. 57) includes gley soils (code 0.72.01), which transition to fluvisols along the Šardický Stream and to regosols on wind-blown sands in the western part.

Geomorphologically, the southern part of the site belongs to the Lower Morava Valley, within the South Moravian Basin unit, Dyje–Morava Upland subunit, and Stupava Floodplain mesoregion. To the east lies the Ratíškovice Upland mesoregion, and to the west, the Central Moravian Carpathians system, Kyjov Upland unit, Mutěnice Upland subunit, and Šardice Upland mesoregion.

Hydrologically, the site is primarily influenced by the nearby Jarohněvický Pond – one of the largest ponds in South Moravia (89.3 ha), located on the Kyjovka River (catchment area: 678.3 km²). The northern part of the site is affected by the right-bank tributary of the Kyjovka, the Šardický Stream (IDVT: 10188890), which is 10.6 km long and has a catchment area of 39 km², with an average flow of 5.0 l/s.

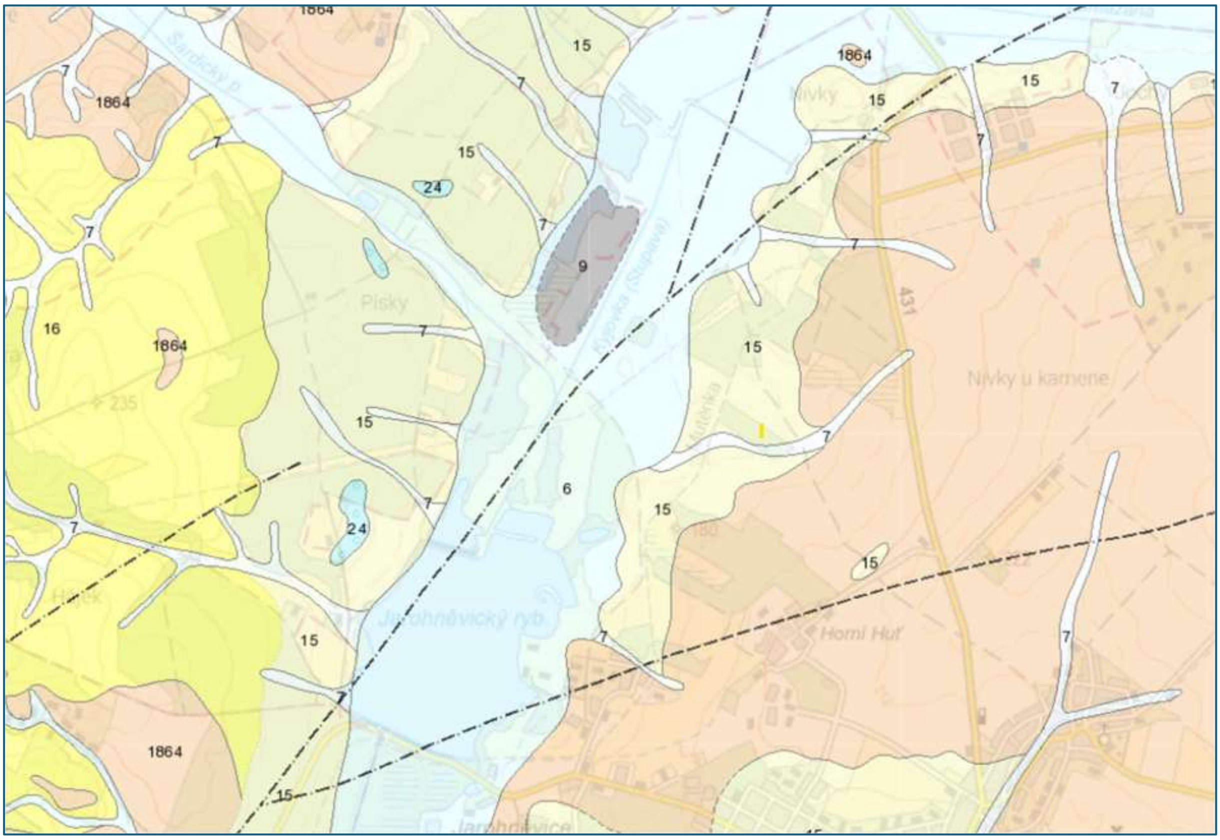

Figure 56: Geological structure of the Ptačí park Kosteliska site (ČGS database); 6 - alluvial unconsolidated sediment (sand, gravel), 7 - delofluvial unconsolidated sediment, 9 - organic unconsolidated sediment (peat), 15 - eolian unconsolidated sediment (silty sand), 16 - aeolian unconsolidated sediment (loess and loess clay), 24 - fluvial unconsolidated sediment (sand, gravel), 1864 - fluviolacustrine unconsolidated sediment (clays, dusty clays, dusty gravels).

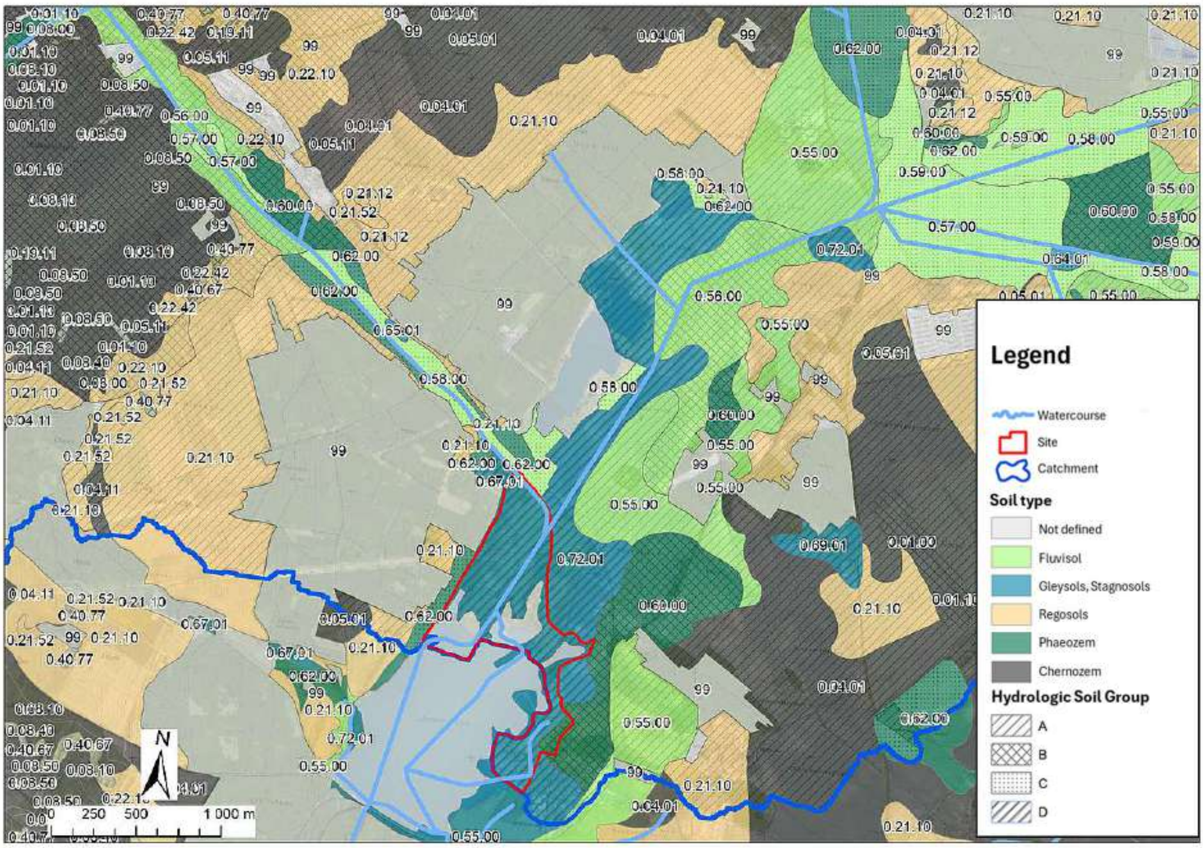

Figure 57: Soil cover in the Kosteliska site

4.9.2. Main Ecological Challenges

The main ecological challenge in the area is to ensure a stable water regime and restore regular flooding, which is essential for maintaining wetland habitats. Changes in the hydrological regime negatively affect biodiversity and require targeted habitat management. Another pressing issue is the control of invasive species, which threaten native vegetation and habitats of rare species.

4.9.3. Pollution Source Analysis

This site spans 64.7 ha and is influenced by a very large catchment area of 32,833.3 ha. The Kyjovka River flows through the area from north to south, along with its tributaries, and several ponds are located along its course. The site is directly affected by the Jarohněvický Pond.

Agricultural land accounts for 48.4% of the catchment area, with arable land making up 41.4% (Fig. 58). This land is extensively drained; data from ZVHS indicate a total of 1,862.1 ha of agricultural drainage systems within the catchment (Fig. 59).

Several municipalities with sewer networks, overflow chambers, discharge points, pumping stations, and wastewater treatment plants (WWTPs) are located within the catchment. Thus, potential sources of pollution include both diffuse agricultural pollution and point-source municipal pollution, which may be transported to the site via the Kyjovka River and the adjacent pond.

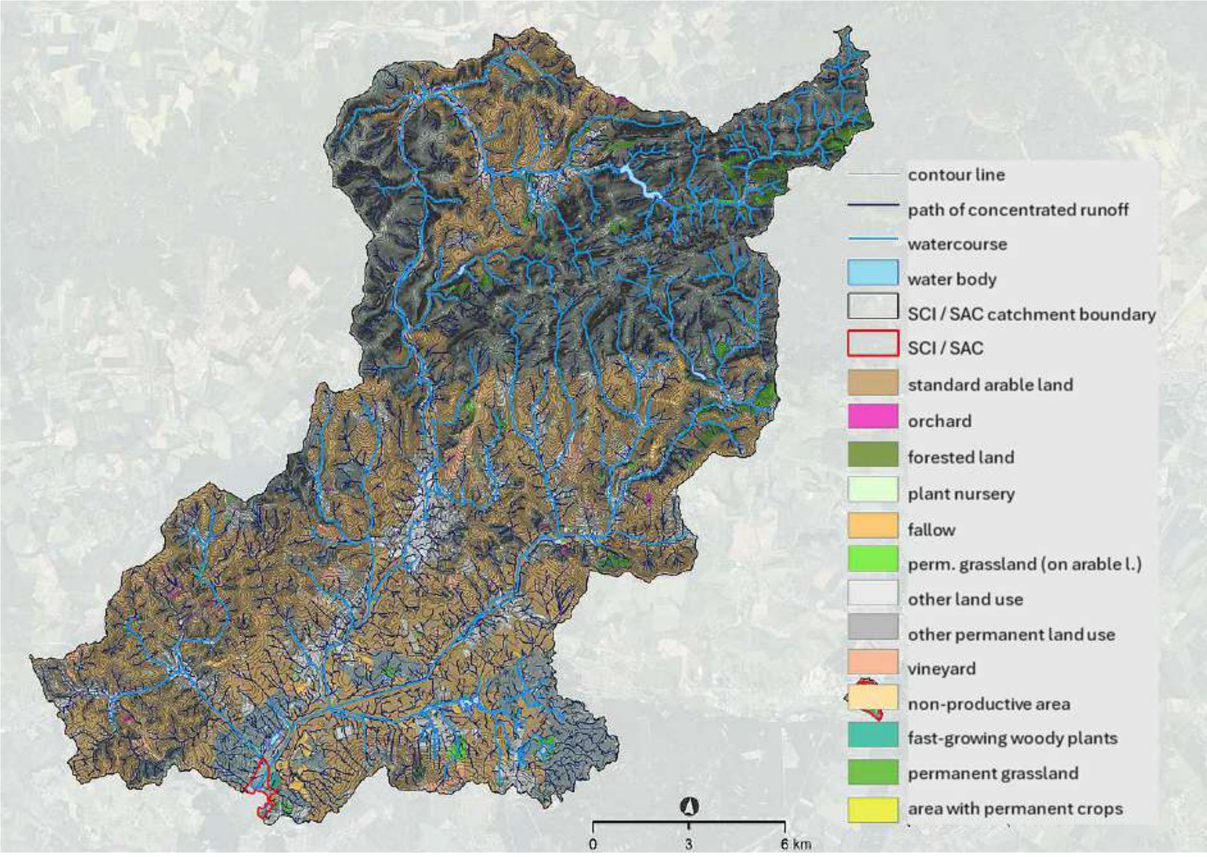

Figure 58: Land use in the catchment of Hodonínská Doubrava SAC

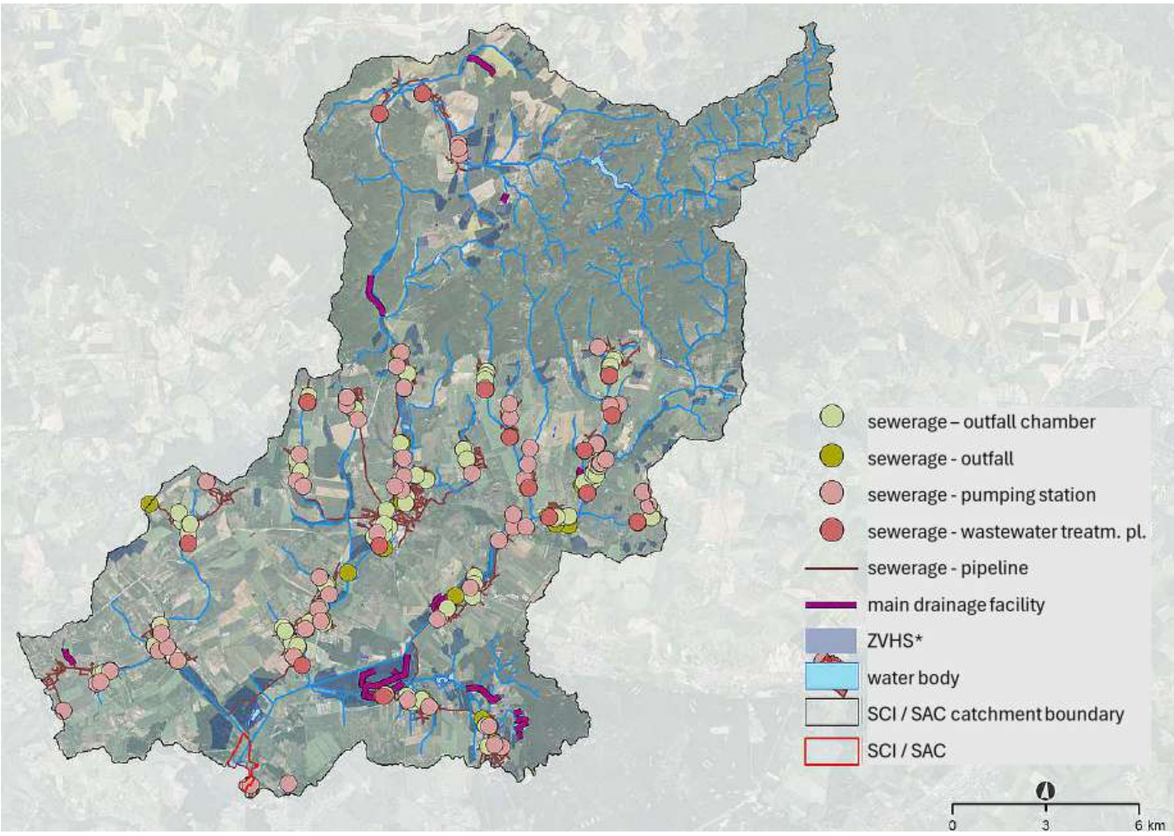

Figure 59: Pollution sources in the catchment of Hodonínská Doubrava SAC

**Former Agricultural Water Management Administration (in Czech ZVHS)*

4.9.4. Water Quality in the Kosteliska Site

Water samples were taken from a pond at the northeastern edge of the site, which is hydrologically influenced by the proximity of the Jarohněvický Pond. Conductivity values (average 940 µS/cm, Class III) indicated moderate ion content. Salinity was relatively low; average sulfate concentrations were 203 mg/l and chlorides 75 mg/l. Ammonium ions were nearly absent (avg. 0.16 mg/l), and nitrate levels were low (avg. 1.6 mg/l). Organic nitrogen concentrations were relatively higher (avg. 2.6 mg/l), especially during summer. The concentrations of both monitored phosphorus forms were moderate among monitored sites: orthophosphates averaged 0.54 mg/l and total phosphorus (P_total) 0.88 mg/l, corresponding to Class V water quality, likely due to the influence of the adjacent large pond. Elevated values were also recorded for COD_Cr (avg. 91 mg O_2/l – Class V) and organic carbon (C_org avg. 18.4 mg/l – Class IV), suggesting organic load from biomass decay. These indicators rose with increasing temperatures in the summer months.

These results indicate that water quality in the Kosteliska SCI is primarily influenced by accumulated biomass in the pond and to a lesser extent by inflow from the nearby Jarohněvický Pond, particularly in relation to phosphorus levels.

Table 13: Average values of monitored water chemical indicators at locality Kosteliska

Parameter / profile	CON (mS/m)	$CHSK_{Cr}$ (mg/l)	Corg (mg/l)	Chlorides (mg/l)	Sulphates (mg/l)	$N\text{-}NH_4^+$ (mg/l)	$N\text{-}NO_3^-$ (mg/l)	N org. (mg/l)	$P_{tot.}$ (mg/l)	PO_4 (mg/l)
Kosteliska	94	90,90	18,44	75	203	0,13	0,36	2,55	0,88	0,54

(*Classification according to Surface water quality classification: ČSN 75 7221–Klasifikace kvality povrchových vod. Úřad pro technickou normalizaci, metrologii a státní zkušebnictví, 2017)*

I	Unpolluted water
II	Slightly polluted water
III	Polluted water
IV	Heavily polluted water
V	Severely polluted water

4.9.5. Measures for Stabilizing the Water Regime and Improving Water Quality

Given the large contributing catchment area (32,833 ha), a significant portion of which is intensively cultivated farmland, along with several settlements and wastewater treatment facilities, water quality in this SCI must be addressed in a broader context. This includes implementing general water protection measures at the regional or national level, such as through the Water Framework Directive. At the local level, water pollution in ponds may be addressed by removing excess biomass, for example through grazing. In future projects, revitalization of the Šardický Stream is recommended.

4.10. SAC VYPÁLENKY

The Vypálenky site (Fig. 60) is a Special Area of Conservation (SAC) under the NATURA 2000 network with the code CZ0623031 and a total area of 65.2914 ha. It is located within the floodplain of the Morava River in the Hodonín District, South Moravian Region. The site is protected as a Natural Monument under national legislation. Vypálenky SAC is important for the conservation of wetland habitats and is home to rare amphibian species such as the European fire-bellied toad (Bombina bombina) and the Danube crested newt (Triturus dobrogicus).

Figure 60. View of SAC Vypálenky, June 2024

4.10.1. Site Description and Contributing Area

The site is located approximately 5 km northwest of Veselí nad Moravou, in the southeastern part of the municipality of Moravský Písek, adjacent to the road connecting Veselí nad Moravou and Moravský Písek, at an elevation of about 170 m a.s.l. It is an irregularly flooded wetland area featuring reed beds and artificial water bodies (ponds). The geological substrate (Fig. 61) in the northern part consists of unconsolidated alluvial sediments (sandy-loamy to gravelly) of Holocene age. In the southern part, aeolian fine sands of Pleistocene age are predominant. In a small section in the northwest corner, anthropogenic fill is present. The dominant soil type is gley soils (0.69.01), with some areas of fluvisols; in parts of the site, soil types were not defined. The soil cover is shown in Fig. 62.

Geomorphologically, the southern part of the site belongs to the Lower Morava Valley, within the South Moravian Basin, Dyje–Morava Upland subunit, and Huštěnovice Upland mesoregion. The northern part, around Road 54, is part of the Dyje–Morava Floodplain subunit and the eponymous mesoregion.

Hydrologically, the site is closed and lacks permanent surface inflow; most water originates from groundwater and precipitation. No inflow from surrounding streams or drainage canals (e.g., Smraďavka to the east, Syrovinka to the south) was detected. In the northwest part, there is an artificial water body and a likely stormwater outlet; wastewater from Moravský Písek is directed to a WWTP in Vracov.

4.10.2. Main ecological challenges

The main ecological challenges include maintaining and improving the water regime, which is essential for amphibian reproduction and the persistence of their populations. Additional challenges involve controlling reed expansion, which threatens the natural heterogeneity of habitats, and removing invasive and expansive woody species that may shade water bodies and negatively affect amphibian larvae development.

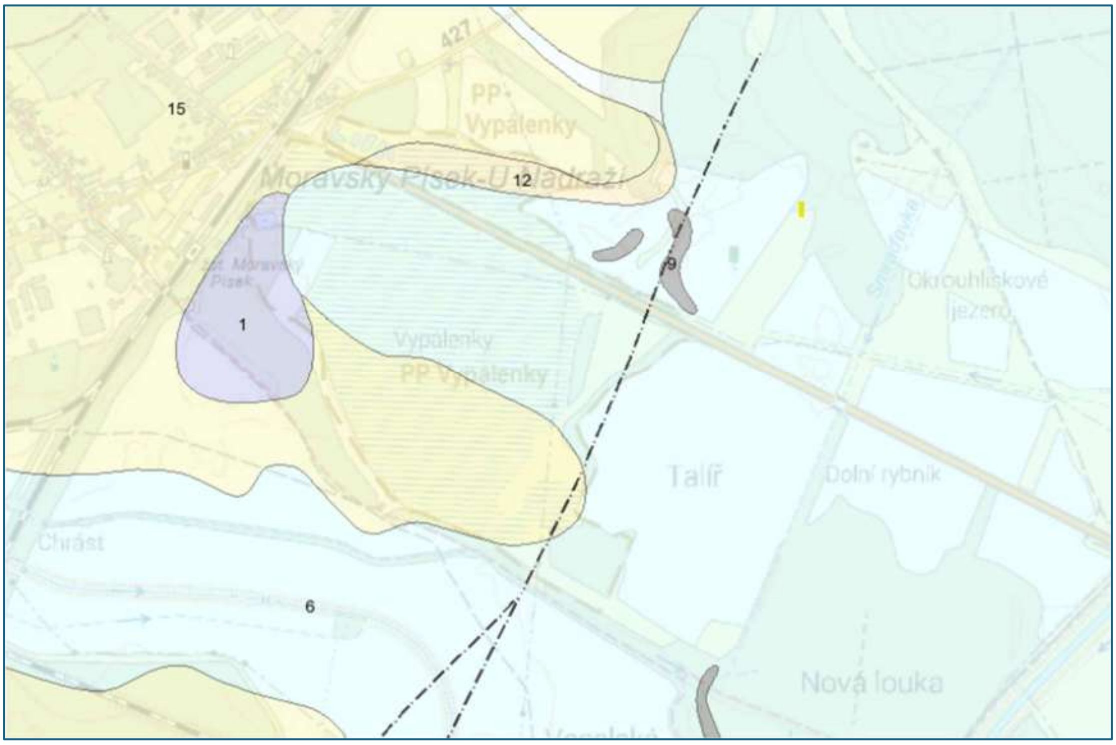

Figure 61: Geological structure of the Vypálenky SAC (ČGS database); 1 – anthropogenic fill, 6 – unconsolidated alluvial sediment, 12 – deluvial unconsolidated sediment (sandy loam to loamy sand), 15 – aeolian unconsolidated sediment (wind-blown sand))

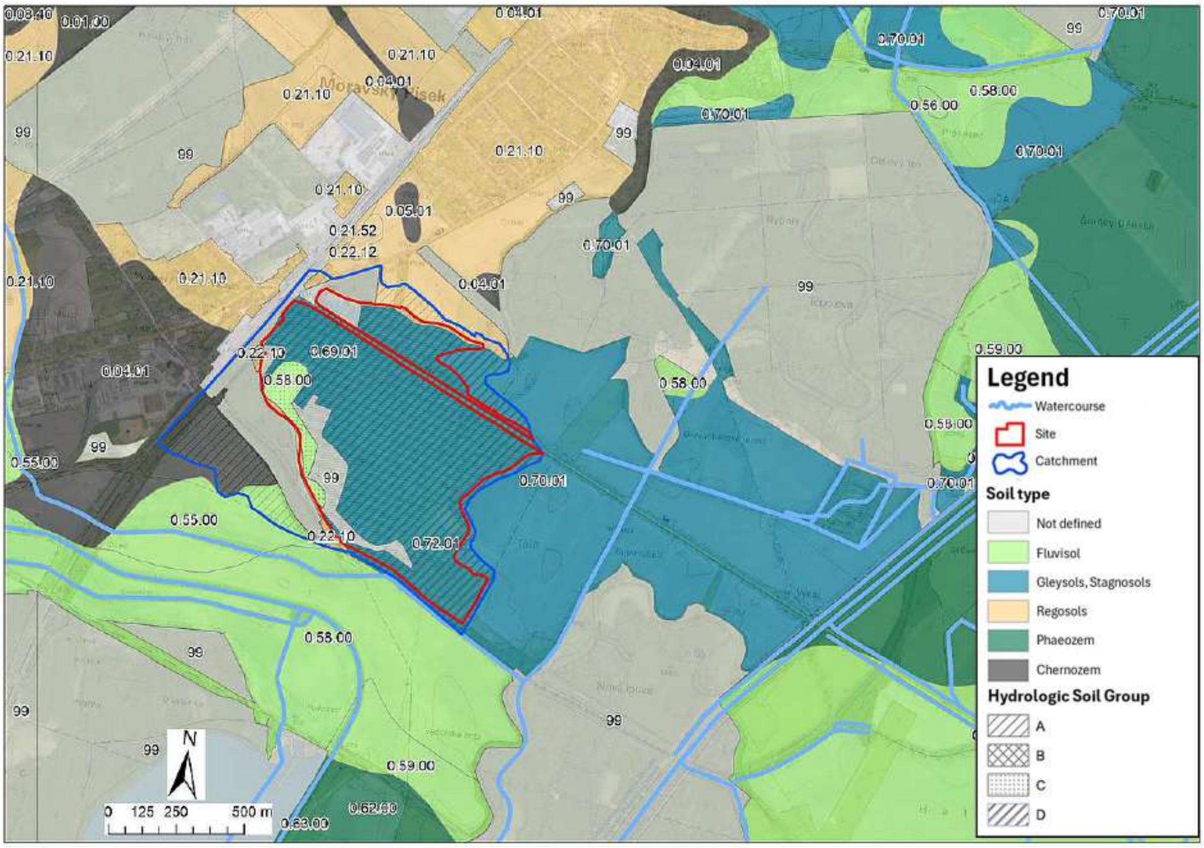

Figure 62: Soil cover of the SAC Vypálenky

4.10.3. Pollution Source Analysis

The Vypálenky SAC spans 65.3 ha and has a contributing catchment of 101.4 ha, only slightly extending beyond the SCI boundaries. According to LPIS data, agricultural land covers just 23.9% of the area (Fig. 63), with arable land comprising only 3.6%. The site is relatively hydrologically isolated, with most water derived from groundwater and precipitation. No inflow from surrounding streams or drainage canals was detected. An artificial pond and a presumed stormwater outlet are located in the northwestern part, while municipal wastewater from Moravský Písek is treated in Vracov. Several minor concentrated runoff paths were identified running northwest–southeast. According to the ZVHS database, no agricultural drainage systems are recorded in the area, and remote sensing analysis confirmed the absence of any such systems.

Regarding potential pollution sources affecting the waters in the Vypálenky SAC (Fig. 64), the main concerns are possible contamination from stormwater drainage from the northern part of the site and runoff from Road 54, which passes through the northeastern section. Agricultural pollution sources are unlikely in this context.

Figure 63: Land use in the Vypálenky SAC catchment

Figure 64: Water pollution sources in the Vypálenky SAC catchment

4.10.4. Water Quality in the Vypálenky SAC

Two monitoring profiles were assessed in the Vypálenky SAC: "Vypálenky Pond" in the southern part and "Vypálenky Control" in the northwestern tip, separated from the main site by Road 54 (Bzenec – Veselí nad Moravou).

Vypálenky tůň

At the Vypálenky Pond profile, relatively high conductivity values were recorded (avg. 1292 µS/cm), corresponding to Class IV water quality. The pond water exhibited high salinity, primarily due to elevated sulfate concentrations averaging 710 mg/l. Chloride levels were substantially lower, averaging 120 mg/l. Nitrogen concentrations were very low, except for organic nitrogen. Ammonium ion levels averaged 0.21 mg/l, and nitrates 2.4 mg/l, indicating neither agricultural nor municipal pollution. Phosphorus levels were also low, with orthophosphates averaging 0.13 mg/l and total phosphorus 0.26 mg/l (Class III). Typical for saline ponds, chemical oxygen demand (COD_Cr) and organic carbon (C_org) were high: average COD_Cr was 113 mg O_2/l and C_org 24.8 mg/l (both Class V), indicating substantial organic pollution from decaying biomass, particularly in summer.

The Vypálenky SCI forms a hydrologically closed system fed mostly by groundwater and precipitation. It was hypothesized that pesticides would be absent. A confirmatory sampling was conducted on June 20, 2024, during the main pesticide application season. Results showed minimal pesticide contamination, with total pesticide concentrations at 0.15 µg/l and only five substances detected in low concentrations (ng/l range).

Vypálenky Control

Samples from this pond were taken during four campaigns. Chemical indicator values were similar to those at the primary site (see Table 14). However, water quality at this location showed lower salinity, conductivity, and COD_Cr values, likely due to the significantly larger surface area of the water body sampled.

Table 14: Average values of monitored water chemical indicators at SAC Vypálenky

Parameter / profile	CON (mS/m)	$CHSK_{Cr}$ (mg/l)	Corg (mg/l)	Chlorides (mg/l)	Sulphates (mg/l)	$N\text{-}NH_4^+$ (mg/l)	$N\text{-}NO_3^-$ (mg/l)	N org. (mg/l)	$P_{tot.}$ (mg/l)	PO_4 (mg/l)
Vypálenky kontrola	88	49,03	16,47	70	170	0,14	0,50	2,85	0,18	0,10
Vypálenky tůň	129	113,02	24,76	120	710	0,16	0,54	2,45	0,26	0,13

(classification according to Surface water quality classification: ČSN 75 7221–Klasifikace kvality povrchových vod. Úřad pro technickou normalizaci, metrologii a státní zkušebnictví, 2017)

I	Unpolluted water
II	Slightly polluted water
III	Polluted water
IV	Heavily polluted water
V	Severely polluted water

Summary of water quality monitoring results

Based on the above results, it can be concluded that the water quality in the SAC Vypálenky is primarily influenced by the amount of decaying biomass in the ponds and the water availability during a particular phase of the season. No evidence of agricultural or municipal pollution was found.

4.10.5. Measures for stabilisation of the water regime and improvement of water quality

Given the fact that no input of polluting substances was detected, only the grassing of remaining small areas of arable land in the catchment of the SAC and the removal of excess biomass, particularly around the ponds, can be recommended to improve water quality.

Another issue addressed in the SAC Vypálenky is the long-term problem of habitat desiccation. This issue cannot be resolved by simple biotechnical measures. Due to the terrain morphology, which slopes towards the southeast, and the position of nearby watercourses, water supply can only be addressed from the northeast, utilising water from the Polešovický Stream. Another potential water source, the Syrovinka Stream, is separated from the area of interest by a low ridge, and other watercourses are dry for a substantial part of the year.

The Polešovický Stream (IDVT: 10200450) is 9.5 km long and has two right-bank tributaries (the Kladíkovský and Domanínský Streams). Based on a detailed analysis of the digital terrain model and other data, a suitable route for the construction of a potential supply channel was proposed – measure VYP 1.

The proposed supply channel is 2,294 m long and begins at a potential intake point on the Polešovický Stream south of road 495, approximately 220 m downstream of the confluence with the Shnilý and Domanínský potok. The route continues approximately 500 m west along a field road, then follows a terrain depression (probably a former stream bed) along the geological boundary between alluvial sediments and aeolian sands. At the border of the SAC catchment, the route turns west again to allow the outfall to reach the site at a sufficient elevation to irrigate a significant portion of the area. The discharge point must be situated directly in the main part of the site, requiring a culverted channel under road 54. From a property rights perspective, the aim was to route the canal primarily through state or municipal land. An overview of affected parcels and ownership types is provided in Table 15. The routing of the canal together with an elevation model is shown in Figure 65. The proposed canal route is illustrated in detail in Figures 66, 67, and 68. A detailed design of the route and technical solution must be the subject of subsequent projects and studies. If this solution is implemented, it will be necessary to analyse and, if needed, treat the water quality of the Polešovický Stream to prevent the introduction of potential pollutants into the area of interest.

Table 15: Overview of parcels affected by the proposed measure for the SAC Vypálenky

Parcel	Land use	Ownership type
2259/1	forest land / protected mineral deposit area	Czech Republic (Lesy ČR)
3724	Waterlogged area	Czech Republic (Lesy ČR)
3723	Arable land	Czech Republic (Lesy ČR)
3719	Other road	Municipality of Moravský Písek
2264	Forest land	Czech Republic (Lesy ČR)
3832	Other road	Municipality of Moravský Písek
3834	Other road	Municipality of Moravský Písek
3817	greenery (other area)	Municipality of Moravský Písek
3842	permanent grassland (nature reserve or monument)	Natural person
3841	permanent grassland (nature reserve or monument)	Natural person
3843	permanent grassland (nature reserve or monument)	Natural person
3840	permanent grassland (nature reserve or monument)	Natural person
3839	permanent grassland (nature reserve or monument)	Czech Republic (ÚZSVM)
3838	permanent grassland (nature reserve or monument)	Natural person
3837	permanent grassland (nature reserve or monument)	Czech Republic (ÚZSVM)
3836	permanent grassland (nature reserve or monument)	Natural person
3816	greenery (other area, nature reserve or monument)	City of Veselí nad Moravou
4054/1	road	Czech Republic (ŘSD)

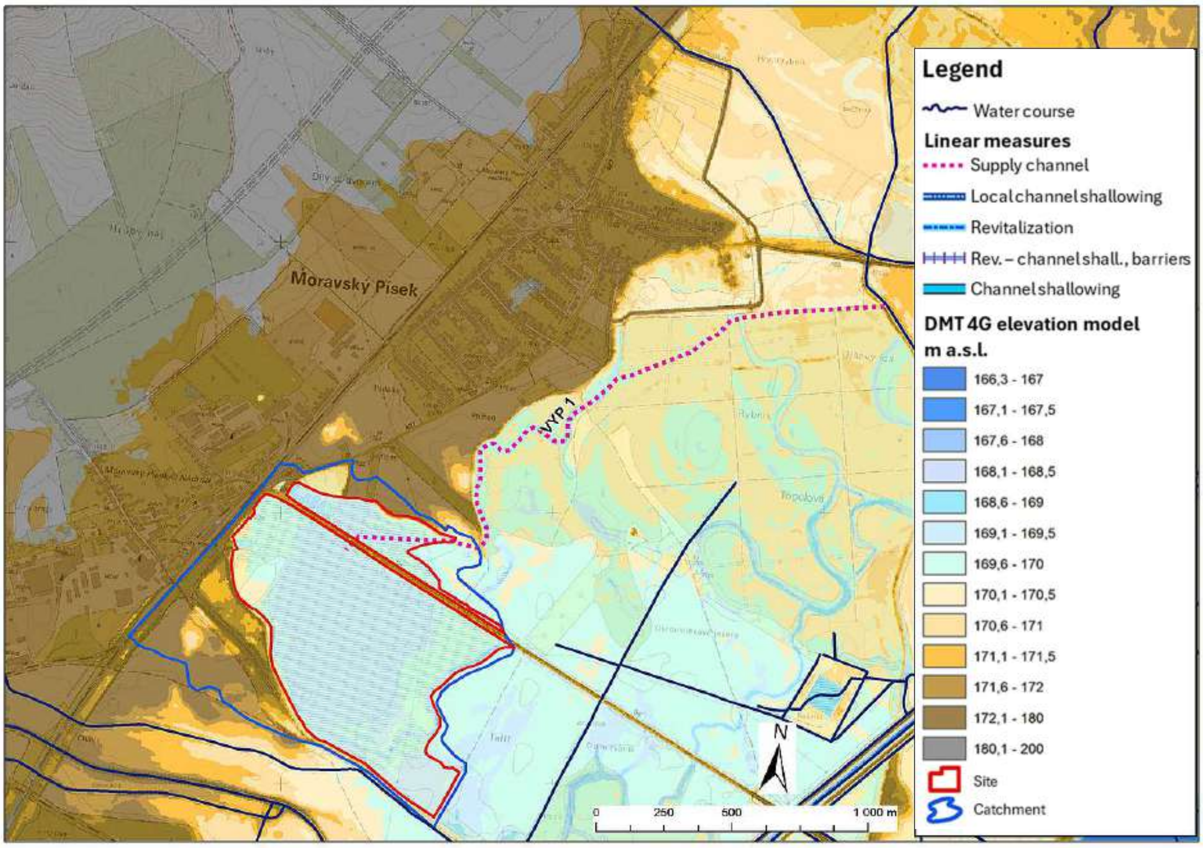

Figure 65: Routing of the supply channel into the SAC Vypálenky based on elevation model

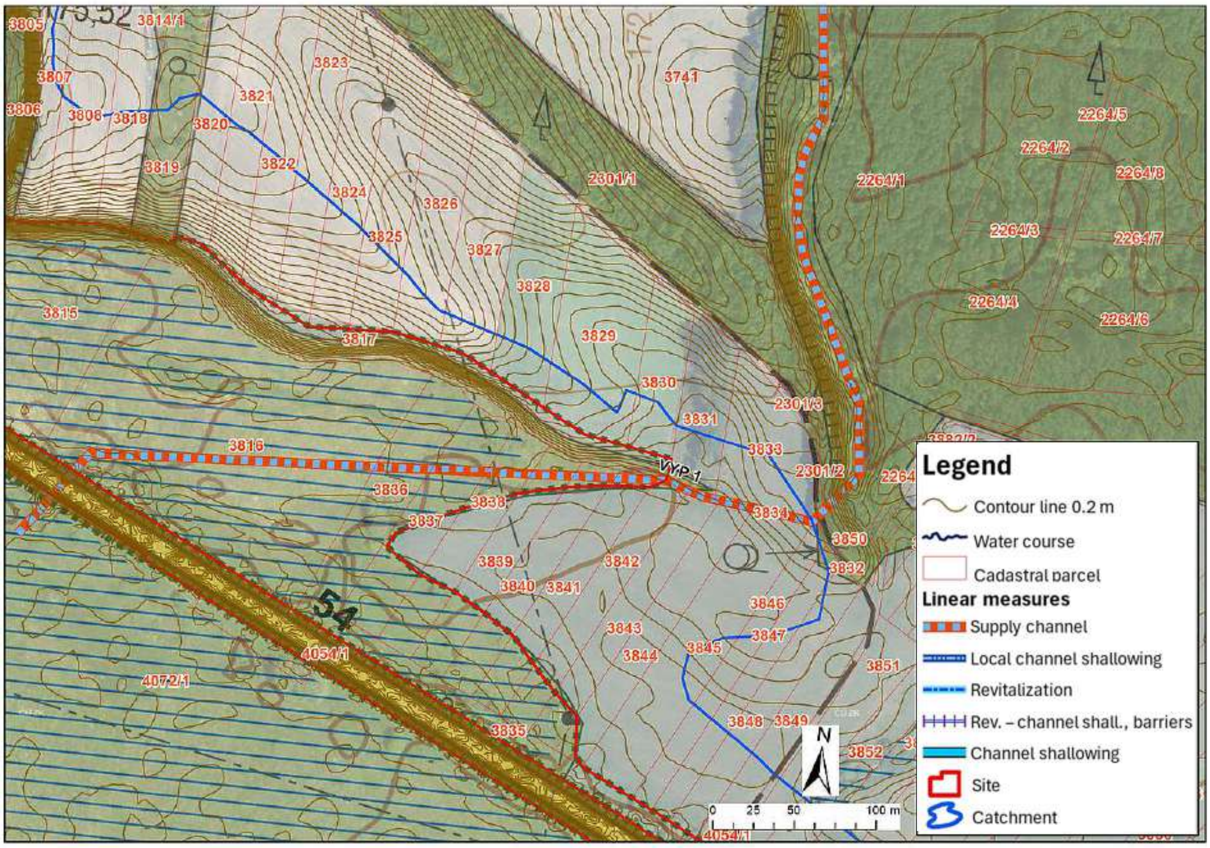

Figure 66: Routing of the western section of the supply channel into the SAC Vypálenky

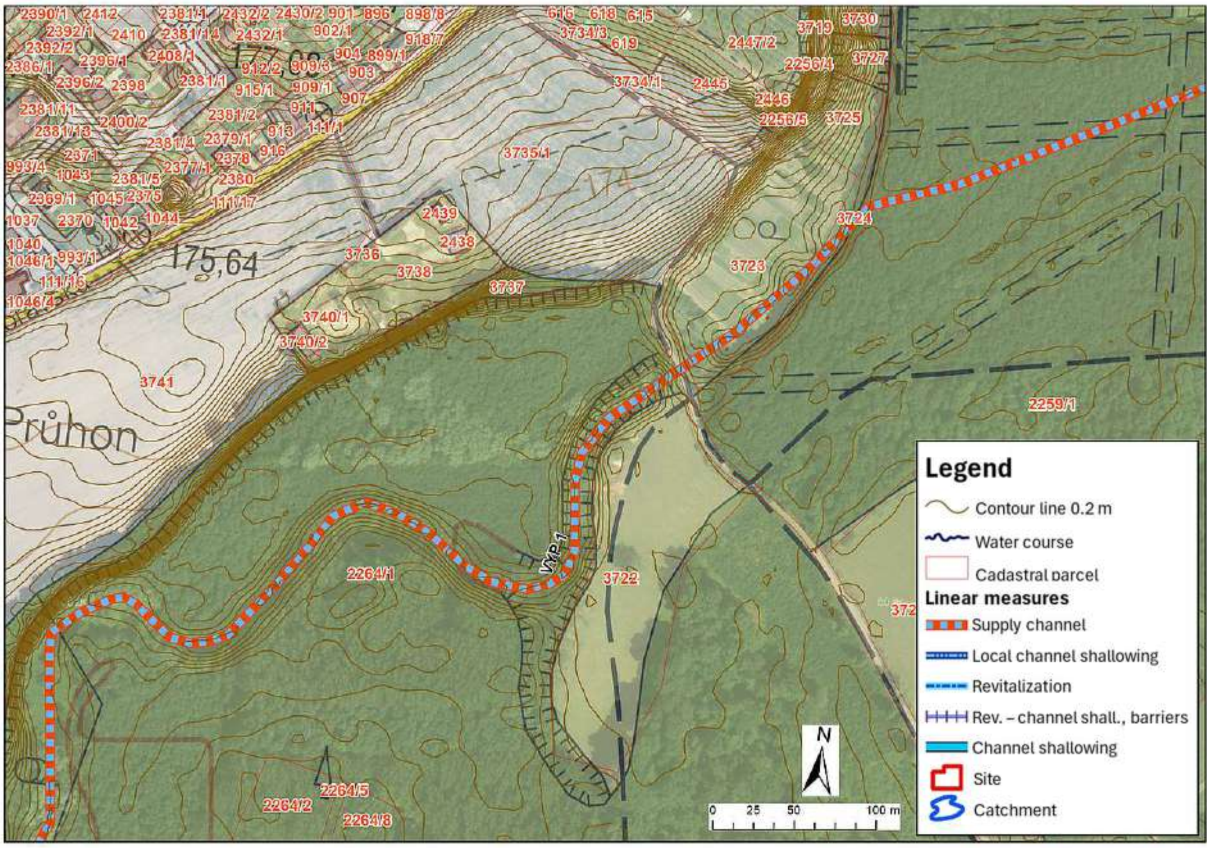

Figure 67: Routing of the central section of the supply channel into the SAC Vypálenky

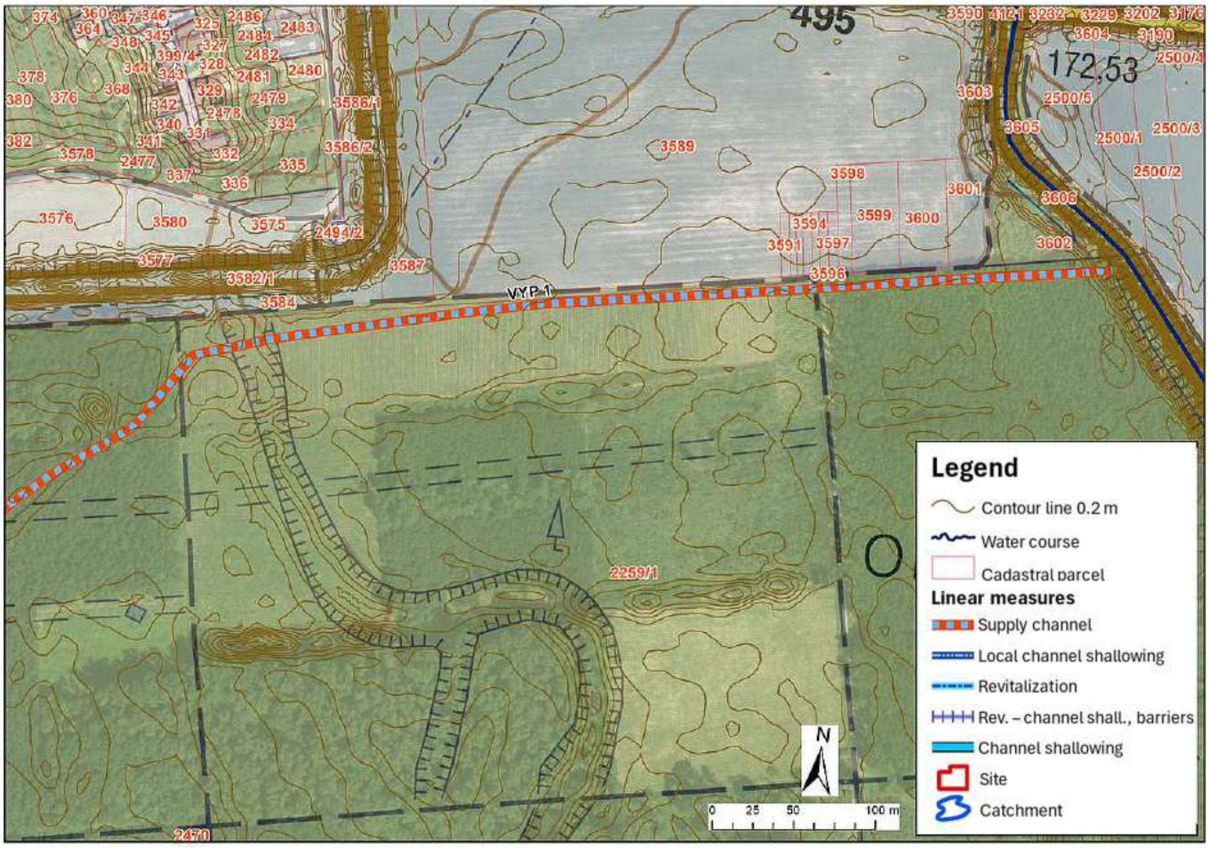

Figure 68: Routing of the eastern section of the supply channel into the SAC Vypálenky

5. CONCLUSIONS

As part of this study, an analysis of the natural conditions of the target areas and their contributing catchments was conducted with respect to the water regime, quantity, and quality of water within the localities and their inflows.

It has been demonstrated that water quality in the South Moravian salt marshes is threatened by several different sources of pollution. Evidence of municipal pollution in some areas is provided particularly by high concentrations of ammonium ions, phosphorus, and extremely high concentrations of glyphosate and its metabolite AMPA (e.g. Bílovický Brook in the SAC Trkmanec–Rybníčky, Vrbovecký Brook in the SAC Vrbovecký rybník, and a pond in the SAC Dobré Pole). In the catchment areas of all these sites, discharge points of local wastewater treatment plants are present. Elimination of pollutant inputs should focus, in addition to the intensification of the treatment plants themselves, especially on the revitalisation of the affected streams to enhance self-purification capacity and on the implementation of appropriate biotechnical measures such as constructed wetlands or root zone treatment systems.

Agricultural pollution is present only in some locations, especially in the pond within the SAC Vrbovecký rybník, which is contaminated with pesticides, as well as the Bílovický Brook in the SAC Trkmanec–Rybníčky, which flows through intensively farmed landscape, and partially in the SAC Hevlínské jezero. In addition to stream revitalisation, the use of protective grassing in agriculturally vulnerable areas is appropriate.

All monitored ponds show significantly elevated concentrations of organic carbon due to large amounts of decaying biomass. Improvement of water quality in these locations is primarily possible through the removal of excess biomass using appropriate management approaches, such as grazing.

Water quality in some localities is mainly affected by large water bodies with exceptionally extensive contributing areas. These include the SAC Kosteliska (linked to the Jarohněvický Pond) and SAC Husí pastviště (hydrologically connected to the confluence of the Svratka and Jihlava rivers and the Middle Reservoir of Nové Mlýny). In such cases, water quality should be addressed at the regional level, particularly through the implementation of General Measures within the entire catchment area on a regional or national scale—for example, via implementation of the EU Water Framework Directive. On a local scale, water pollution in ponds can be addressed by removing excess biomass, such as through grazing.

Based on the results of site analysis, water quality assessment, and both field surveys and remote sensing, systems of measures were proposed in suitable areas to improve the water regime of the target sites, reduce the input of pollutants into the salt marshes, and generally enhance water quality in the assessed areas.

A total of 51 measures were proposed, of which 9 are point-based, primarily comprising two biofilters designed to reduce the pollutant load of water entering the localities, and distribution and regulation structures. Of the 19 linear measures, most are revitalisation interventions on small watercourses and drainage channels. These include deepening and cleaning of watercourses, and in suitable locations, adjustments to their alignment. A total of 24 area-wide measures were proposed. Most of these aim to change land use in ways that affect water quality in the target sites. Other measures include the construction of artificial wetlands to improve water quality.

The objective of the proposed interventions is to improve the ecological condition of the areas of interest. The authors aimed to design functional systems of measures regardless of their feasibility within the framework of the Life In Salt Marshes project. During the project, four of these measures are intended to be implemented and subsequently evaluated for their effectiveness. The selection of measures to be realised within the project will be based on discussions among the project team and stakeholders from the respective localities. Additional measures will be recommended for implementation through public funding and follow-up projects.

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Zajíček, A., Fučík, P., Kaplická, M., Liška, M., Maxová, J., Dobiáš, J. (2018): Pesticide leaching by agricultural drainage in sloping, mid-textured soil conditions - the role of runoff components. WATER SCIENCE AND TECHNOLOGY. 77 (7), p 1879-1890. DOI: 10.2166/wst.2018.068

6.2. Data Sources

Aerial imagery - Letecké snímky:

archive aerial photos - archivní letecké snímky (ALMS) – ČÚZK - Archiv

mapping services from Google and Mapy.cz - mapové služby od společnosti Google a Mapy.cz

Czech Geological Survey -Česká geologická služba (ČGS)

Geologic maps - Geologické mapy 1: 50 000 (Lite) - Geologická mapa 1 : 50 000 (Lite)

database of geologically documented objects - databáze Geologicky dokumentované objekty- geology.cz/app/gdo/

Geoscientific maps - Geovědní mapy 1:50 000- Geovědní mapy 1 : 50 000

State Land Office - Státní pozemkový úřad ČR

Data on land development - Údaje o pozemkových úpravách - Pozemkové úpravy | Geoportál SPÚ

Water management structures - Vodohospodářské stavby - Vodohospodářské stavby | Geoportál SPÚ

Public land registry - Veřejný registr půdy

LPIS - (Land Parcel Identification System) - LPIS

Map portal of VÚMOP, v.v.i.- Mapový portál VÚMOP, v.v.i

Soil in maps

Catalogue of measures - Katalog opatření

Katalog opatření PVL

Geomorphological division of the Czech Republic - Geomorfologické členění České republiky

Mapová prohlížečka firmy ESRI - Geomorfologické členění ČR - Přehled

Data on agricultural drainage structures - Údaje o stavbách zemědělského odvodnění

Data bývalé ZVHS - http://eagri.cz/public/web/mze/farmar/LPIS/data-melioraci/

Data VÚMOP, v.v.i. - Informační systém melioračních staveb - ISMS

Státní Okresní archiv Břeclav - Státní okresní archiv Břeclav se sídlem v Mikulově – Moravský zemský archiv v Brně

Státní Okresní archiv Znojmo - Státní okresní archiv Znojmo – Moravský zemský archiv v Brně

Data on watercourses in the area under consideration - Údaje o vodotečích v řešeném území

Vodohospodářský informační systém VODA - ISVS Voda

Water supply and sewerage development plan of the South Moravian Region - Plán rozvoje vodovodů a kanalizací Jihomoravského kraje (PRVK JMK)

PRVK JMK

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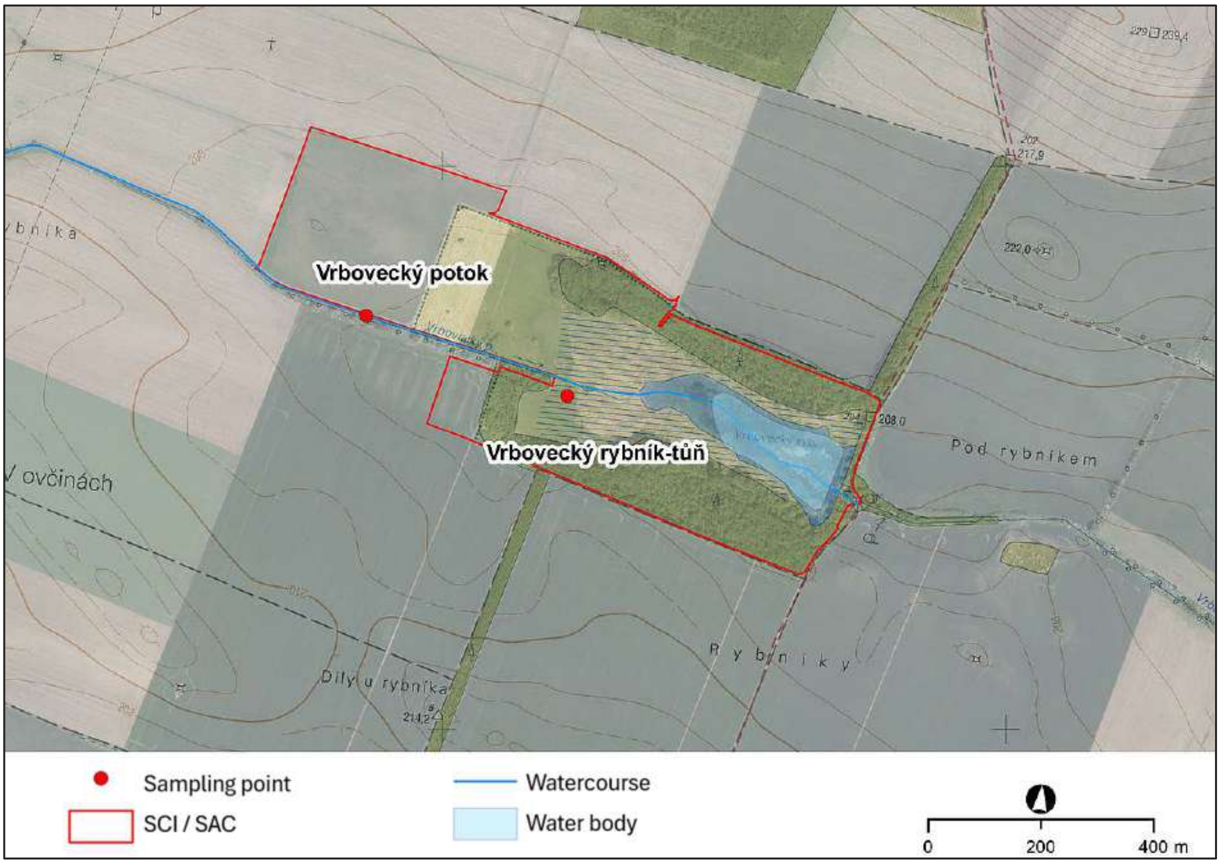
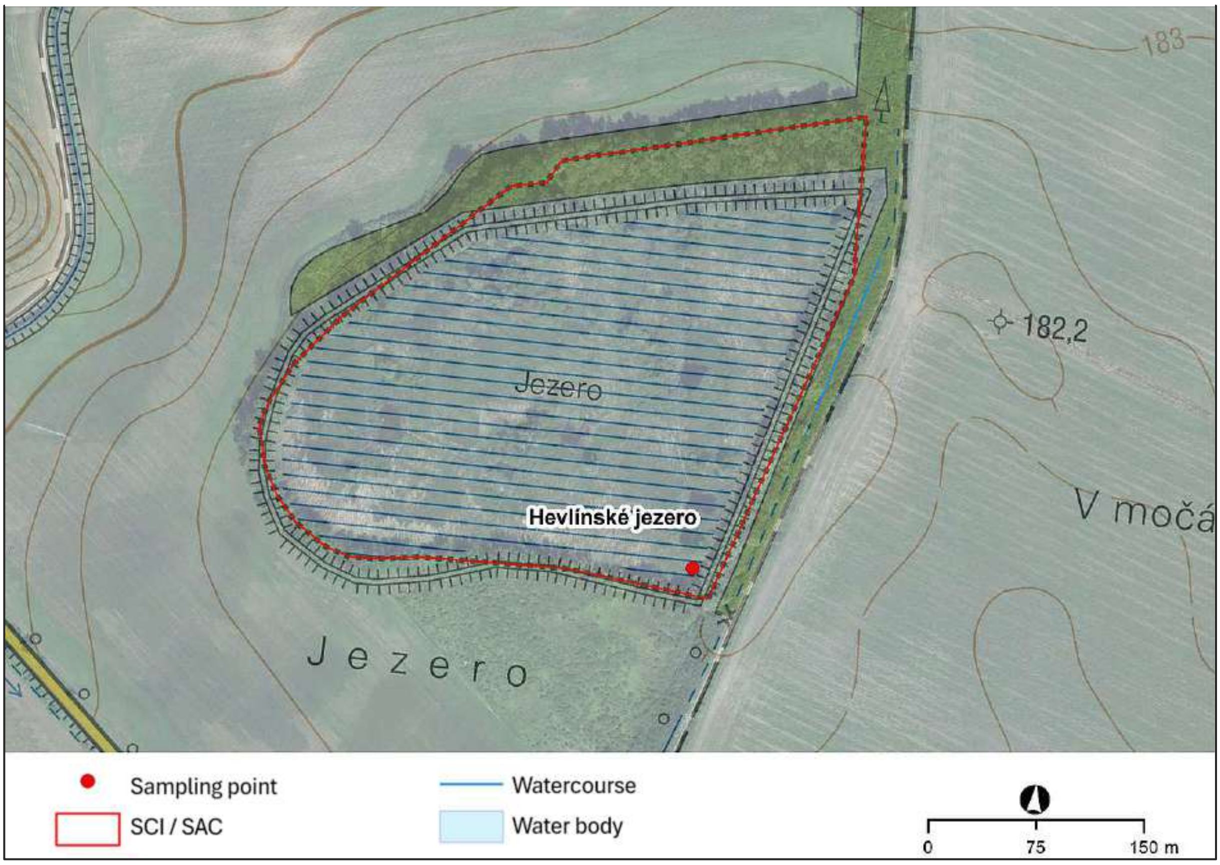
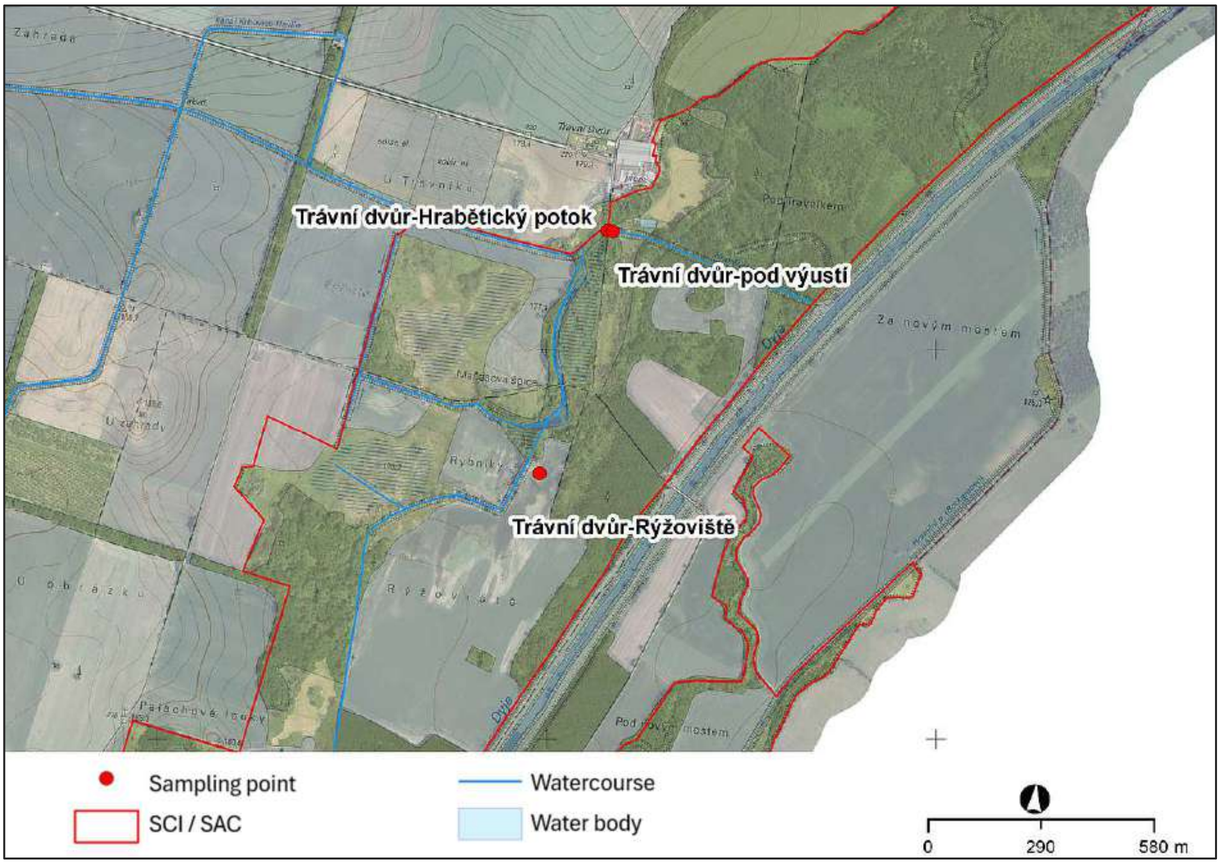


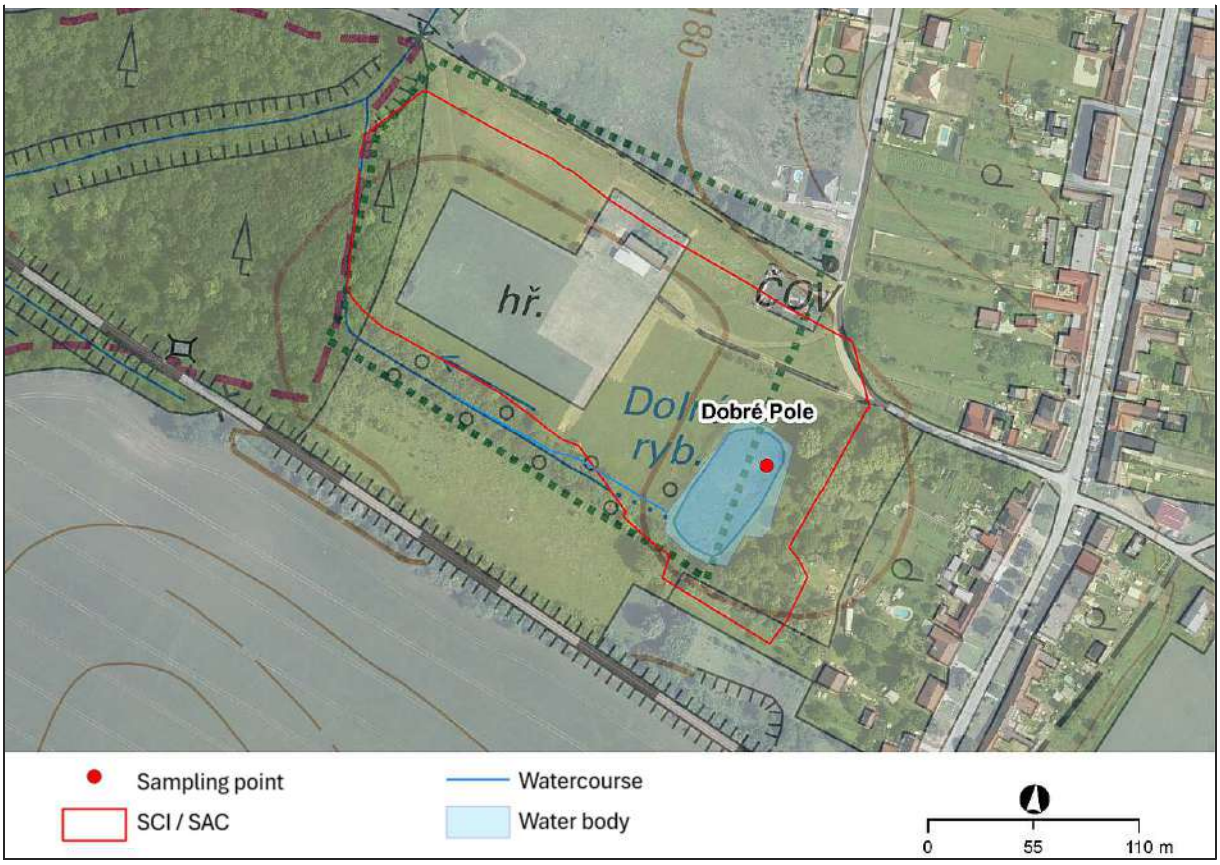
Overview of sampling points at SAC Vrbovecký rybník



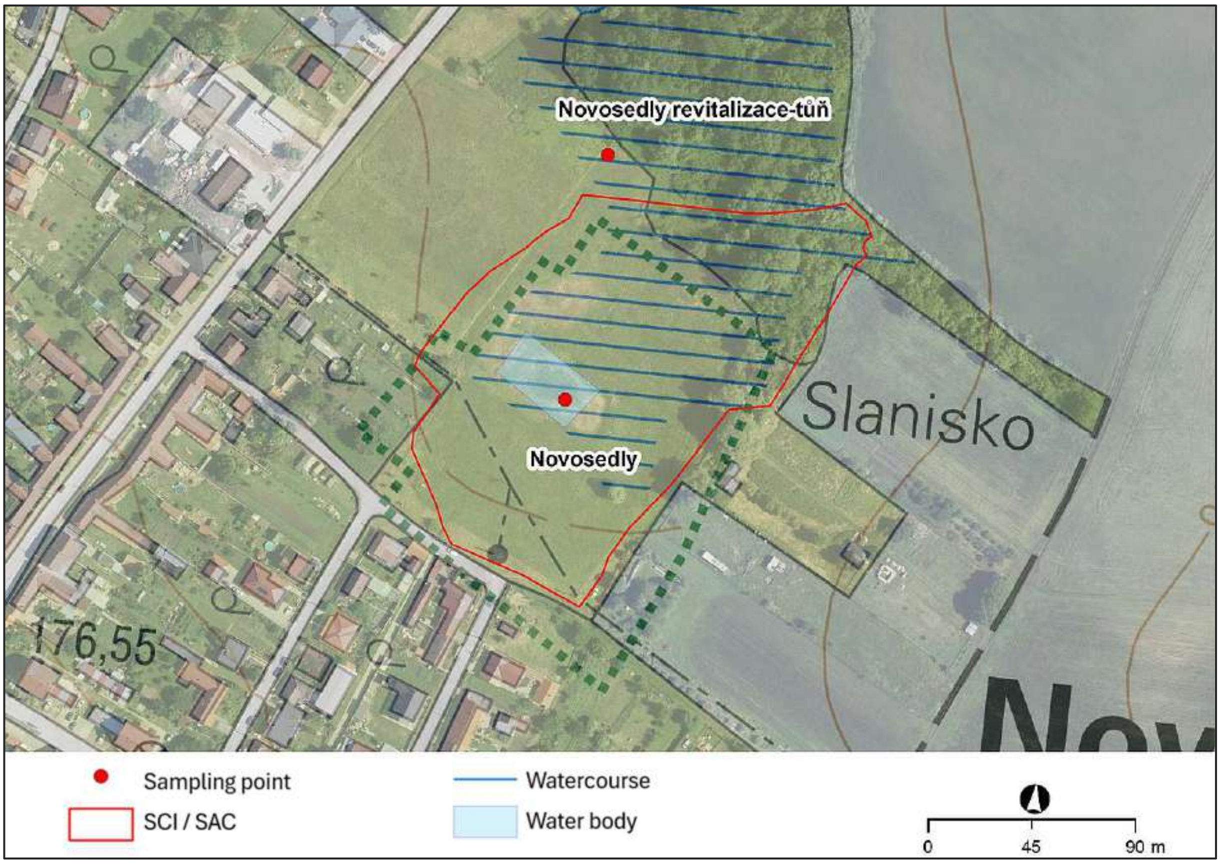
Overview of sampling point at SAC Hevlínské jezero



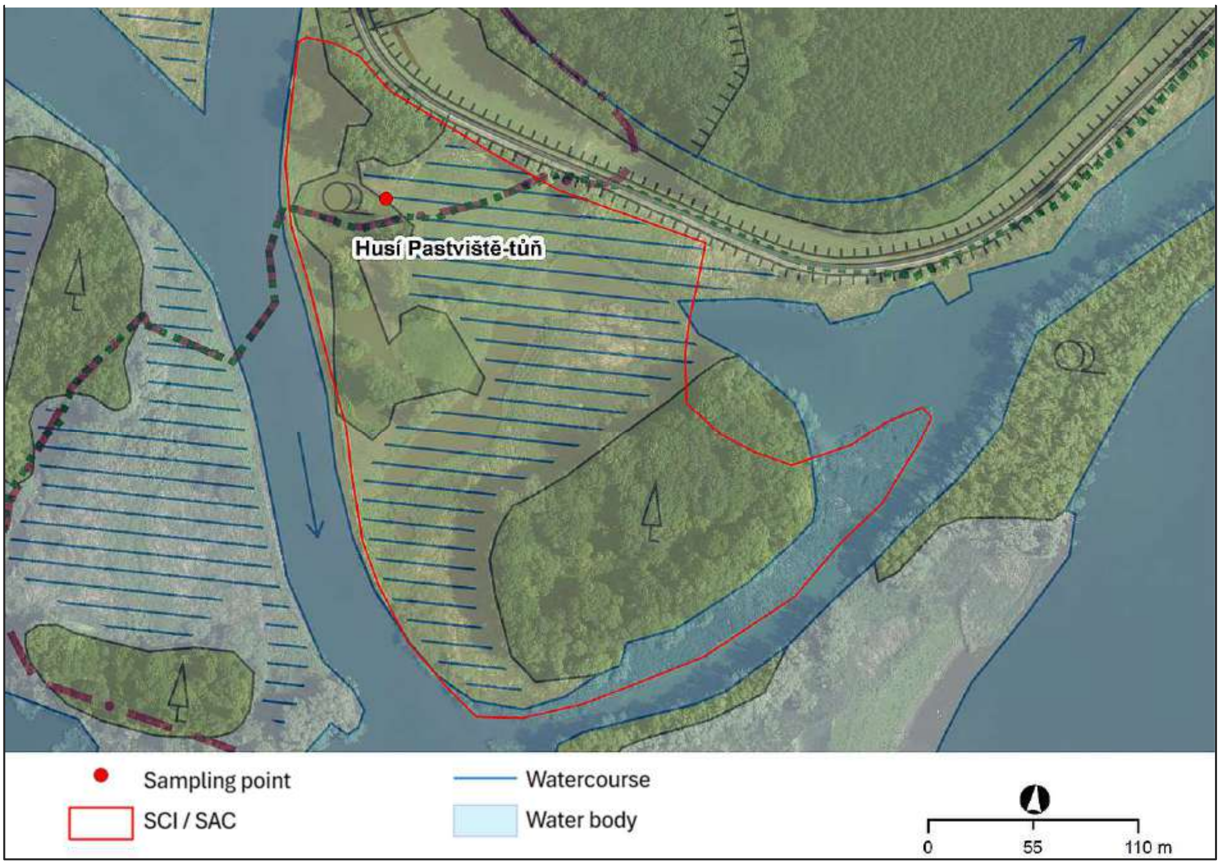
Overview of sampling points at SAC Trávní dvůr



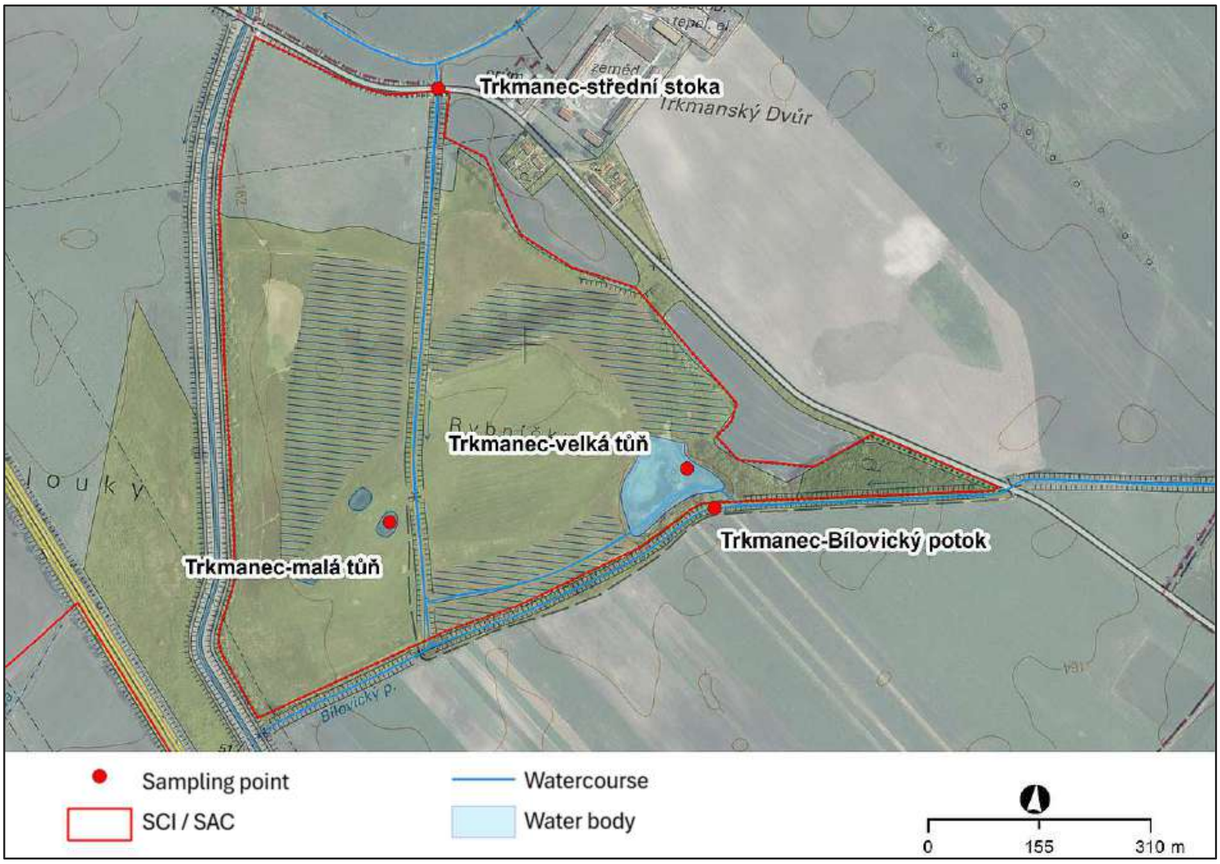
Overview of sampling point at SCI Slanisko Dobré Pole



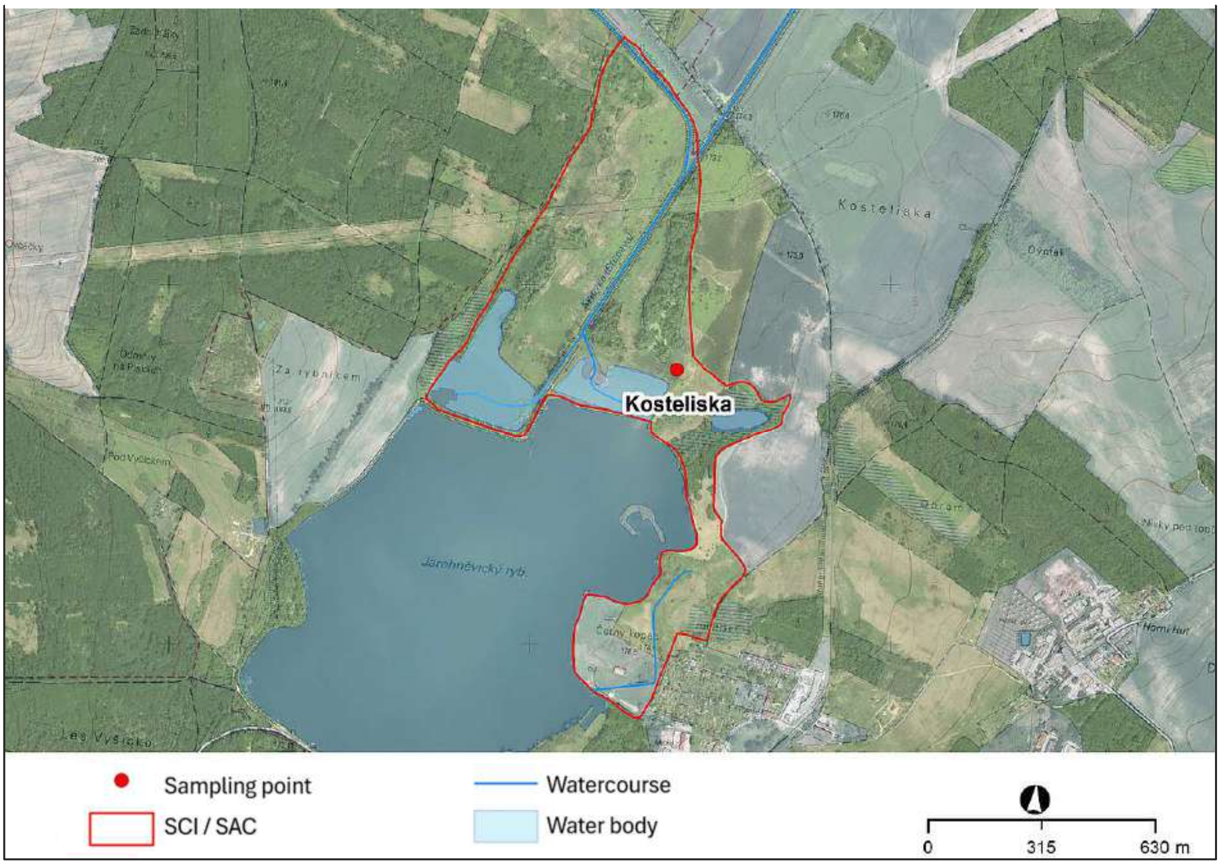
Overview of sampling points at SAC Slanisko Novosedly



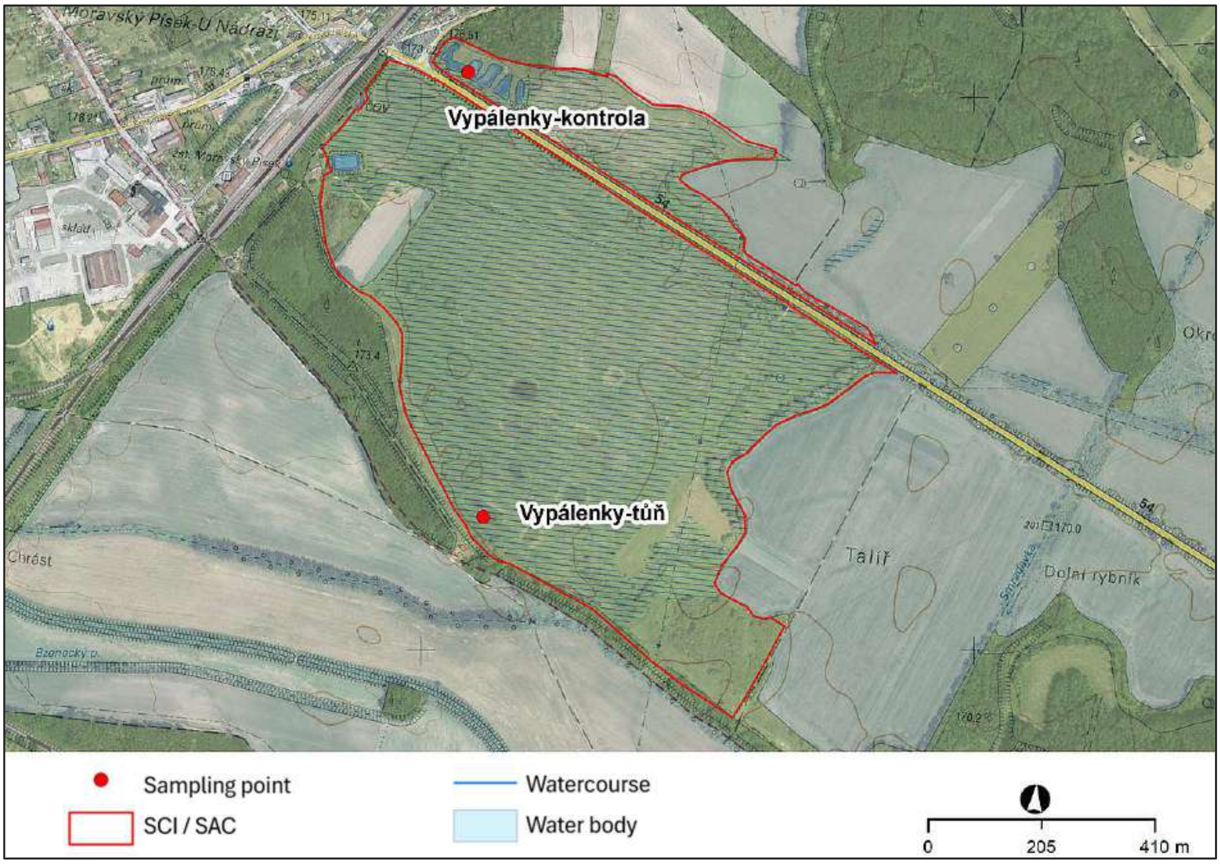
Overview of sampling point at locality Husí pastviště



Overview of sampling points at SAC Trkmanec Rybníčky



Overview of sampling point at locality Kosteliska



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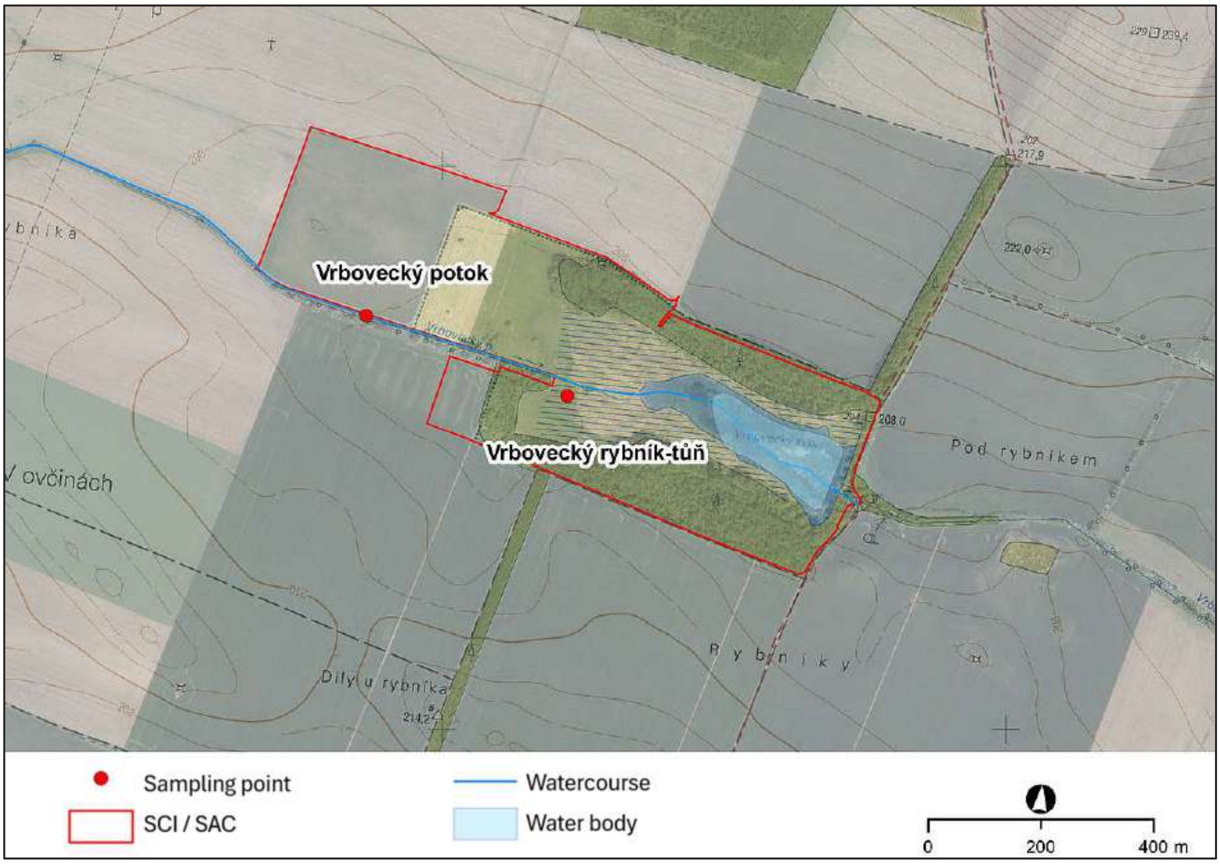
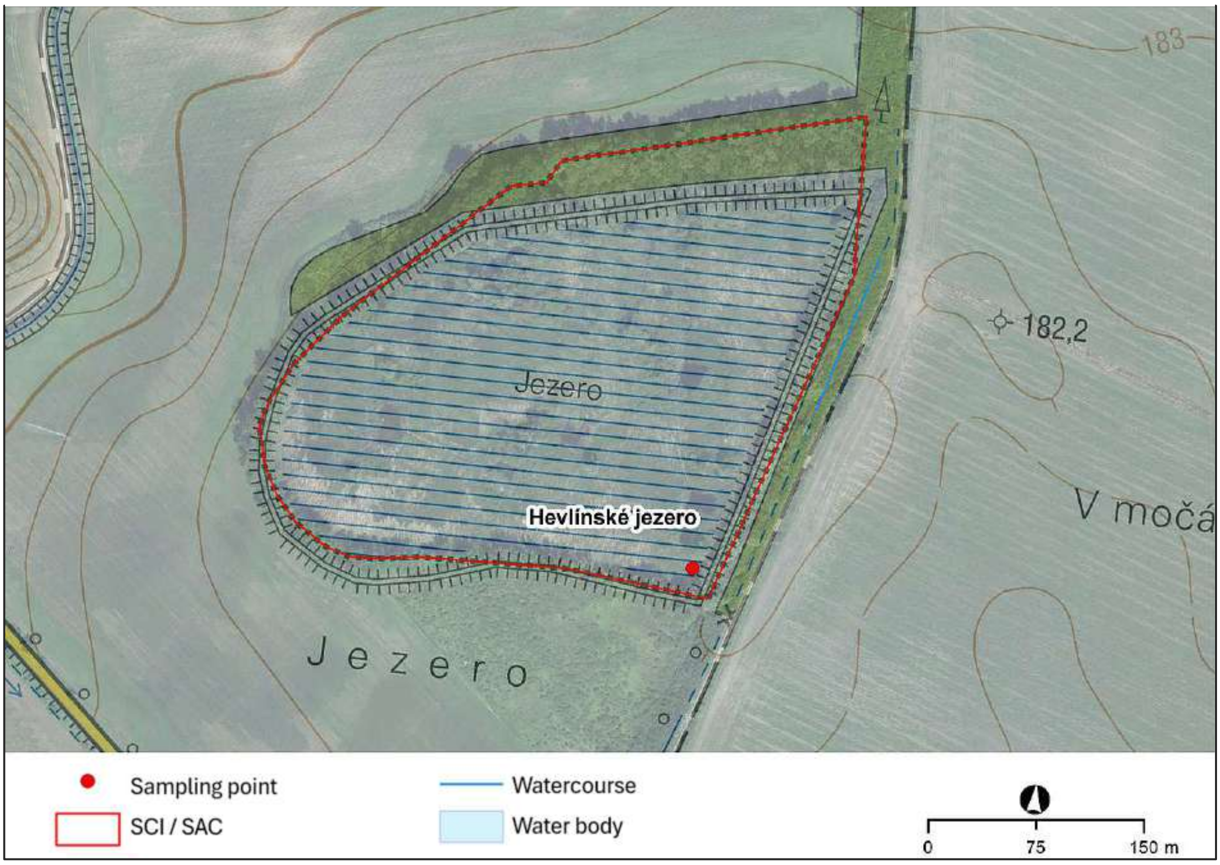
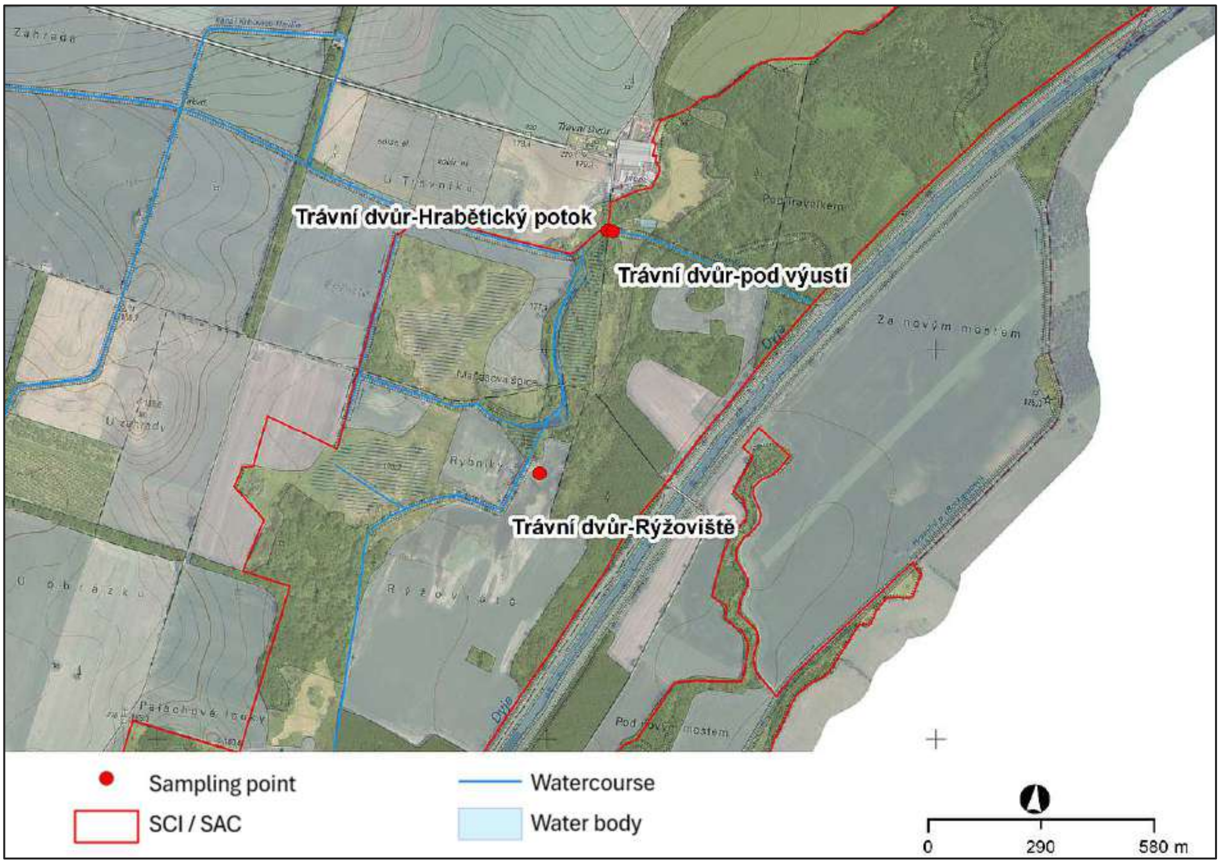


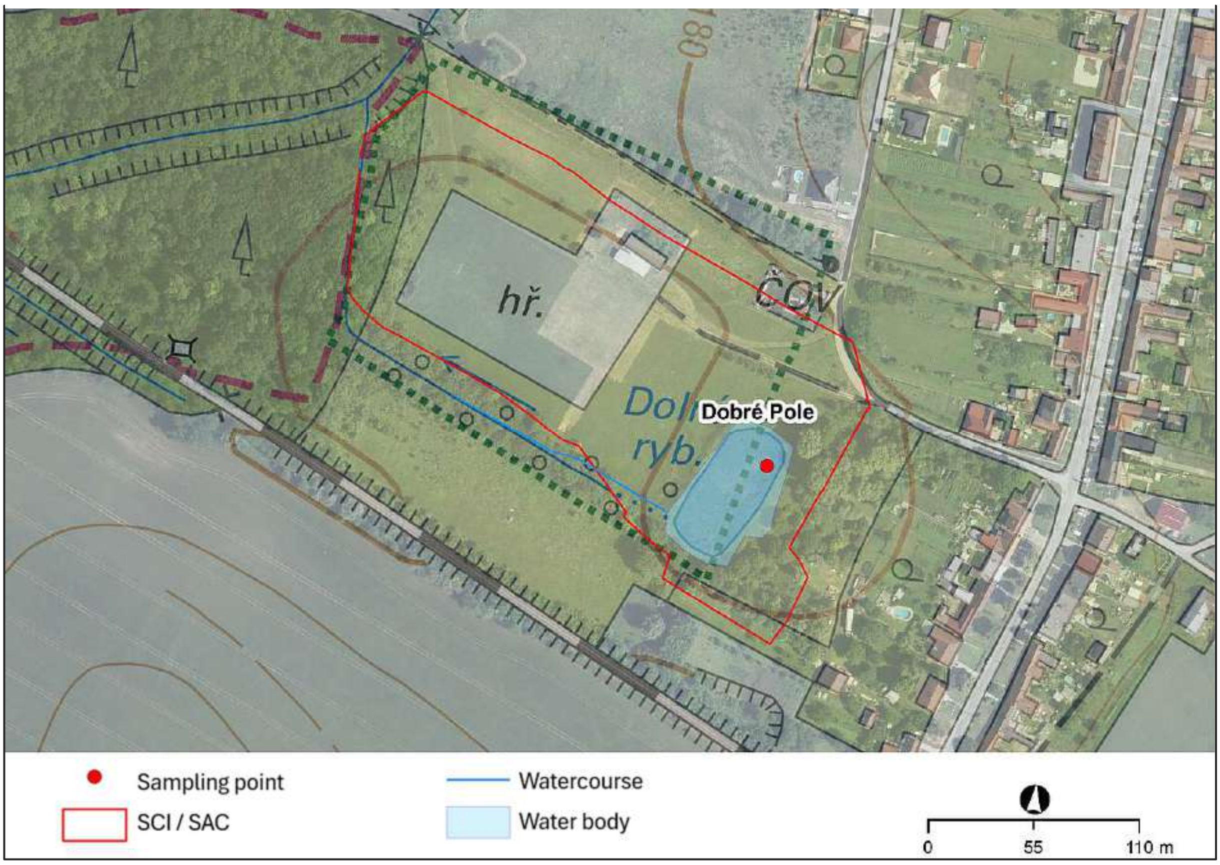
Overview of sampling points at SAC Vrbovecký rybník



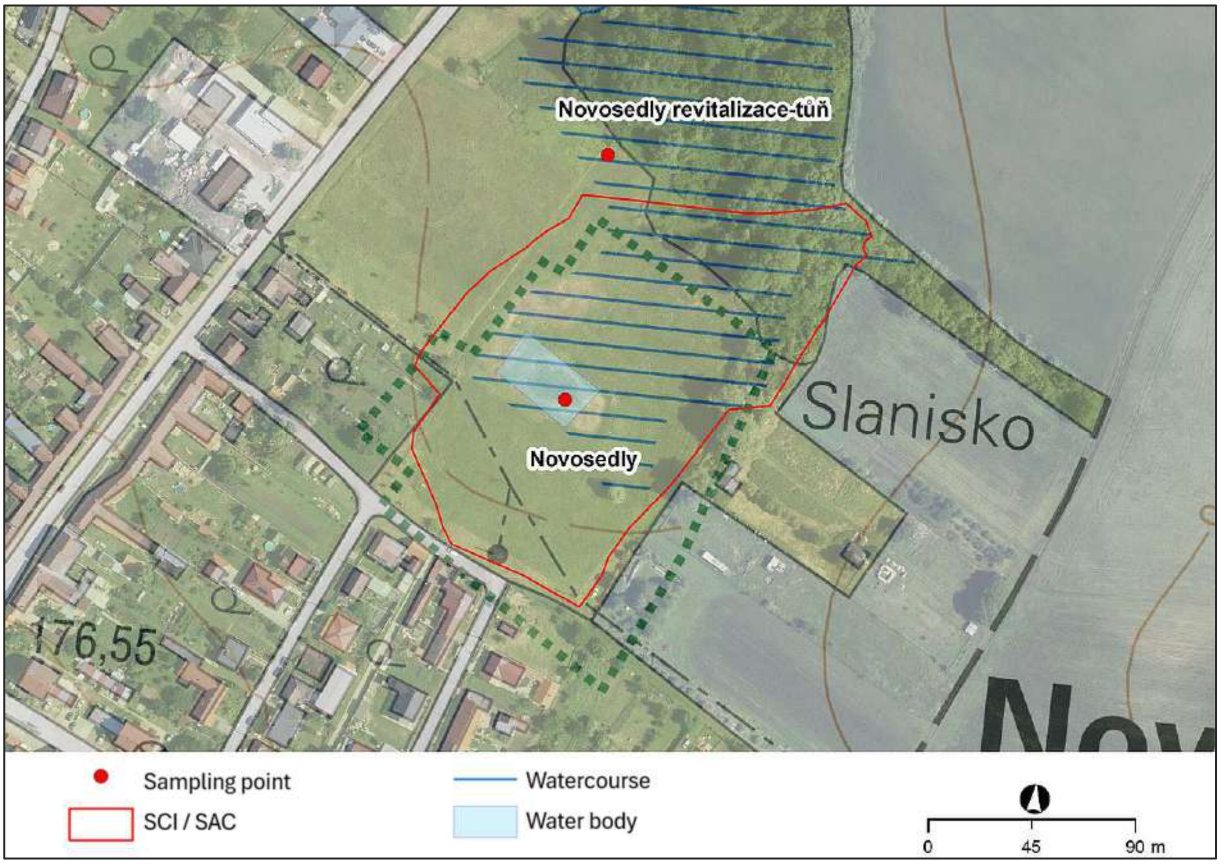
Overview of sampling point at SAC Hevlínské jezero



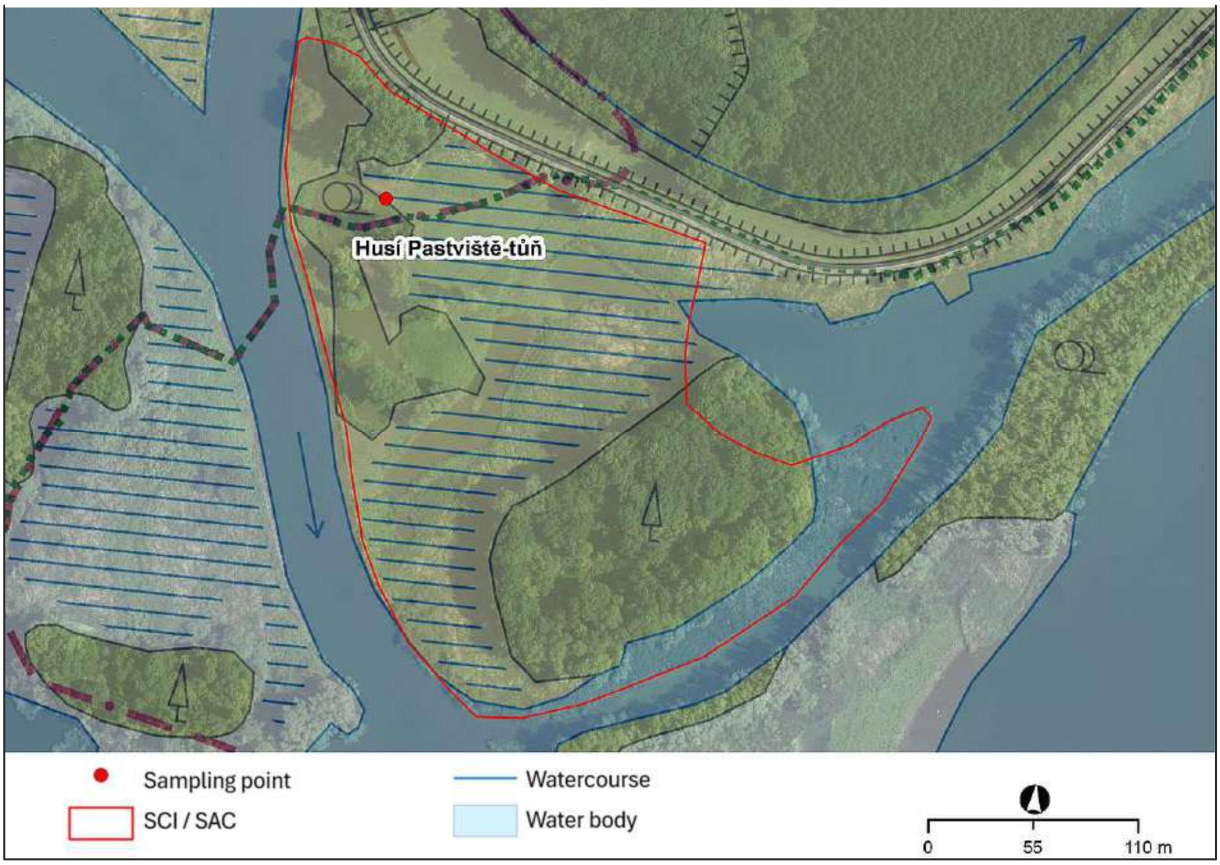
Overview of sampling points at SAC Trávní dvůr



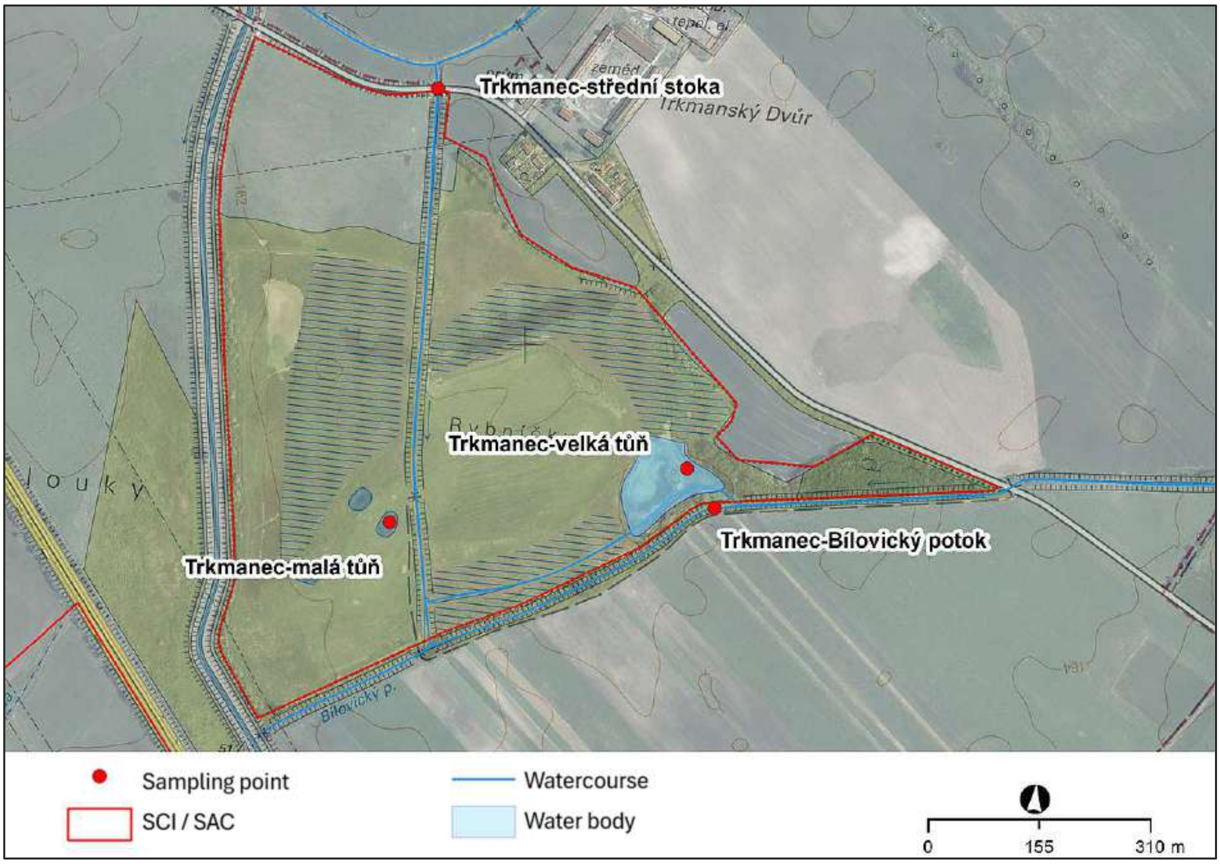
Overview of sampling point at SCI Slanisko Dobré Pole



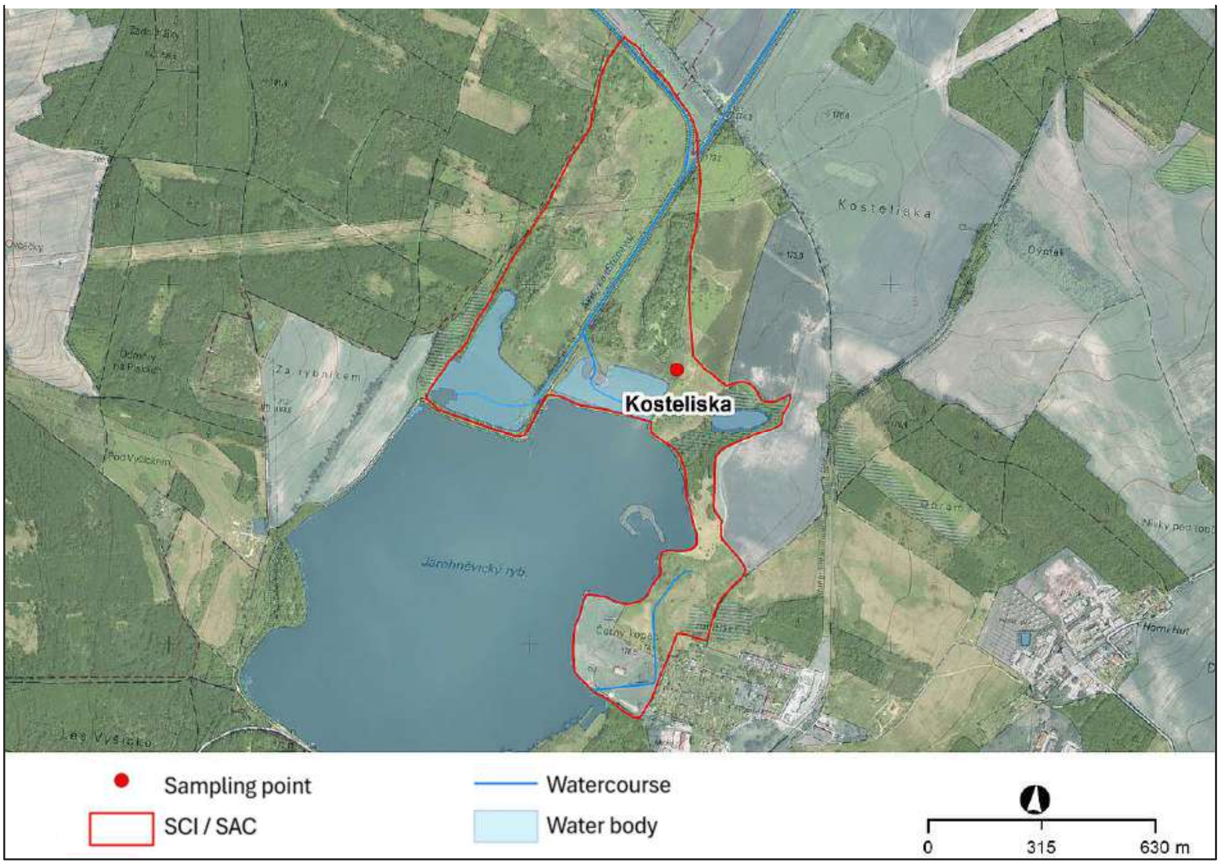
Overview of sampling points at SAC Slanisko Novosedly



Overview of sampling point at locality Husí pastviště



Overview of sampling points at SAC Trkmanec Rybníčky



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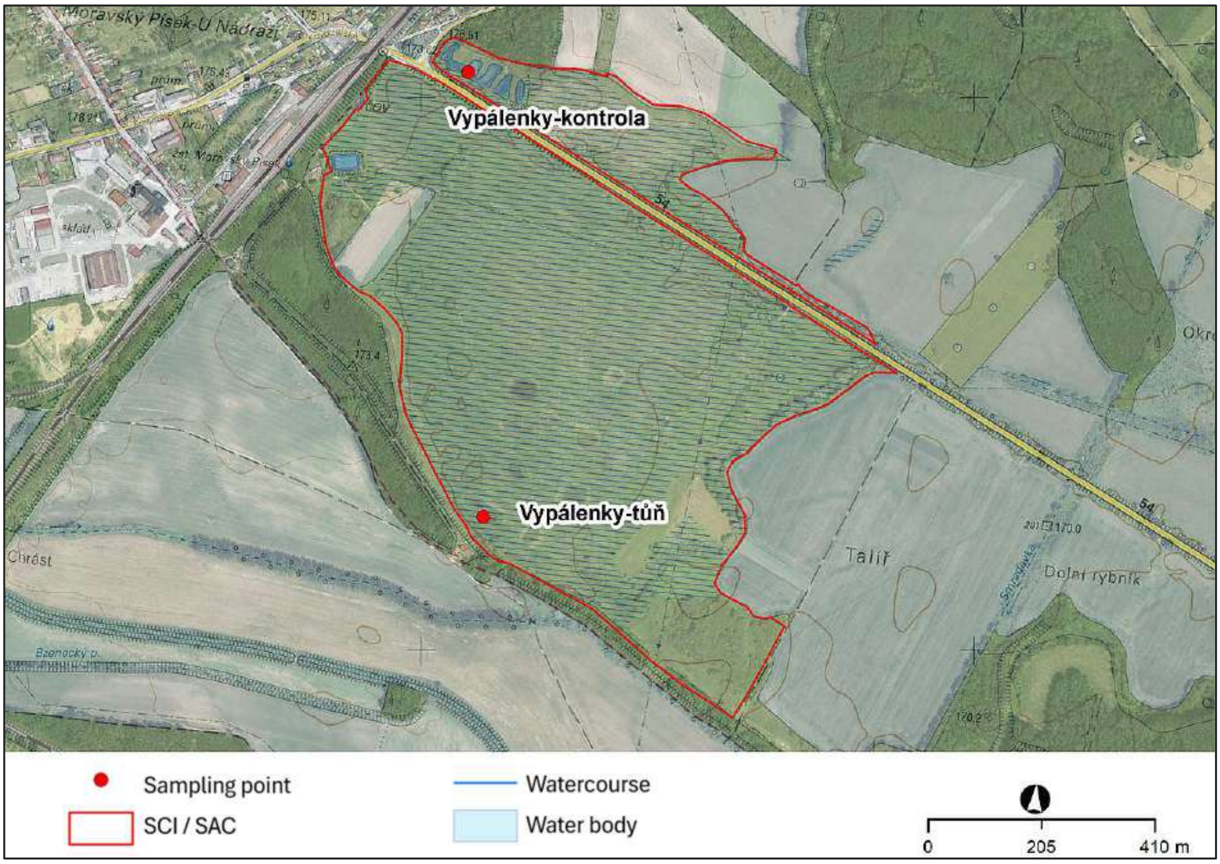

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