

Soil and crop management choices for the Koprzywianka River catchment in Poland based on modelling approaches

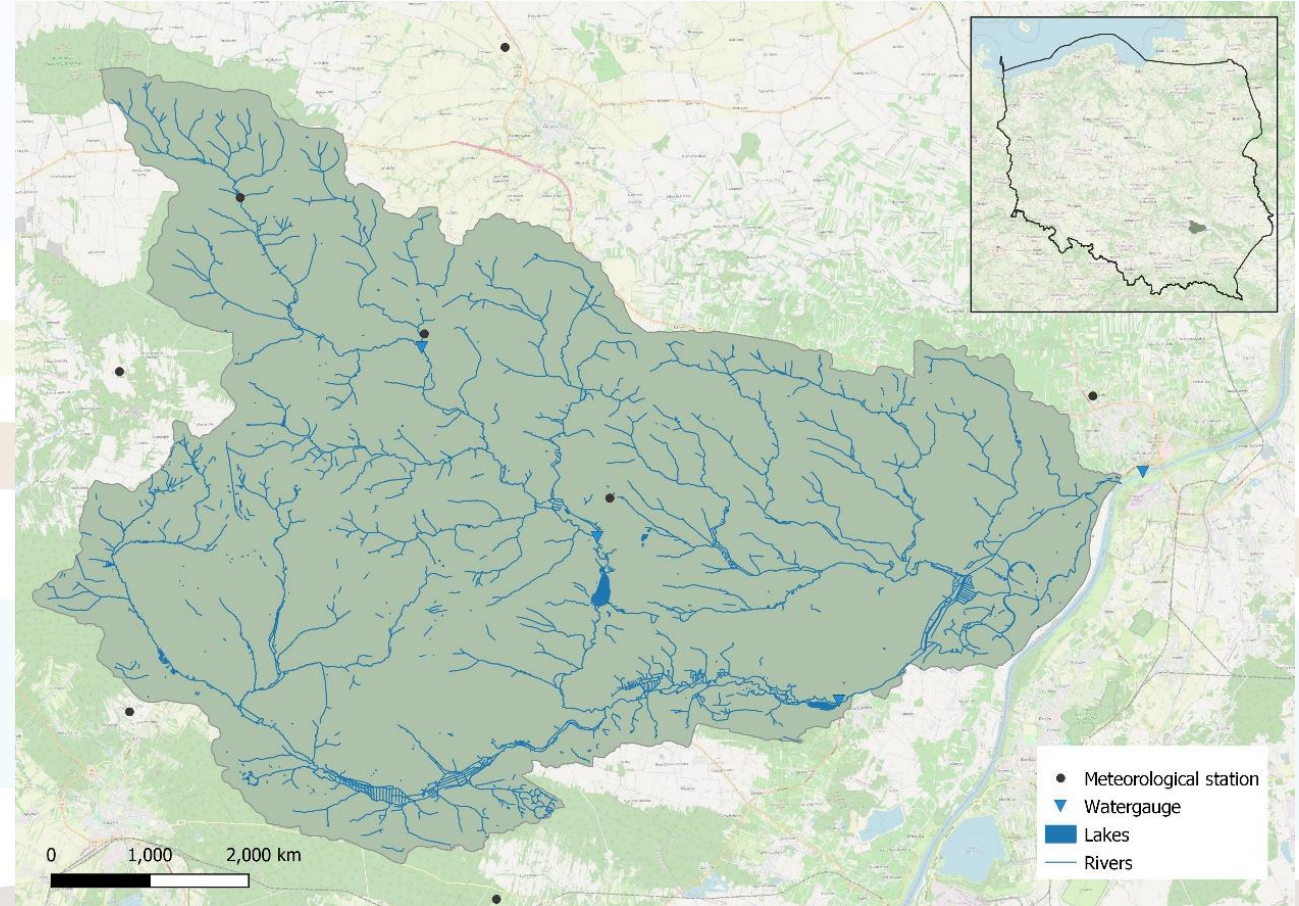


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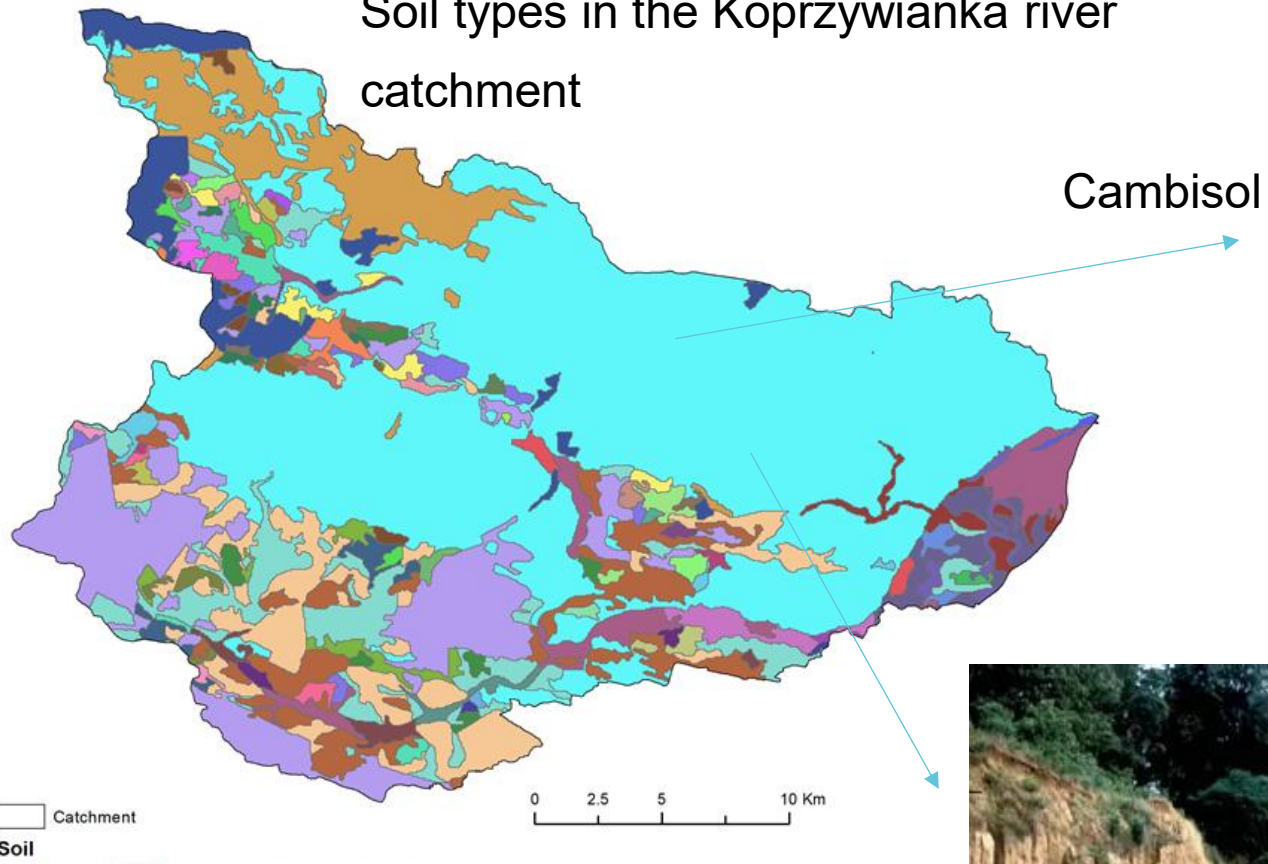
- The Koprzywianka catchment of 708 km² area is located in the south-eastern part of Polish and in the south-eastern part of the Świętokrzyskie Voivodeship



Test site – Koprzywianka - Model boundaries for MikeShe



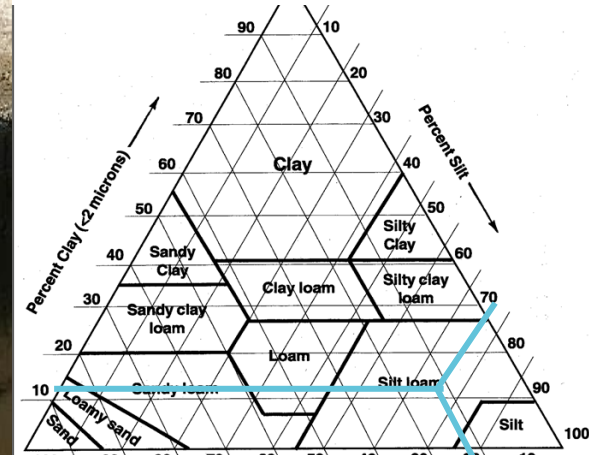
Soil types in the Koprzywianka river catchment



Histosols

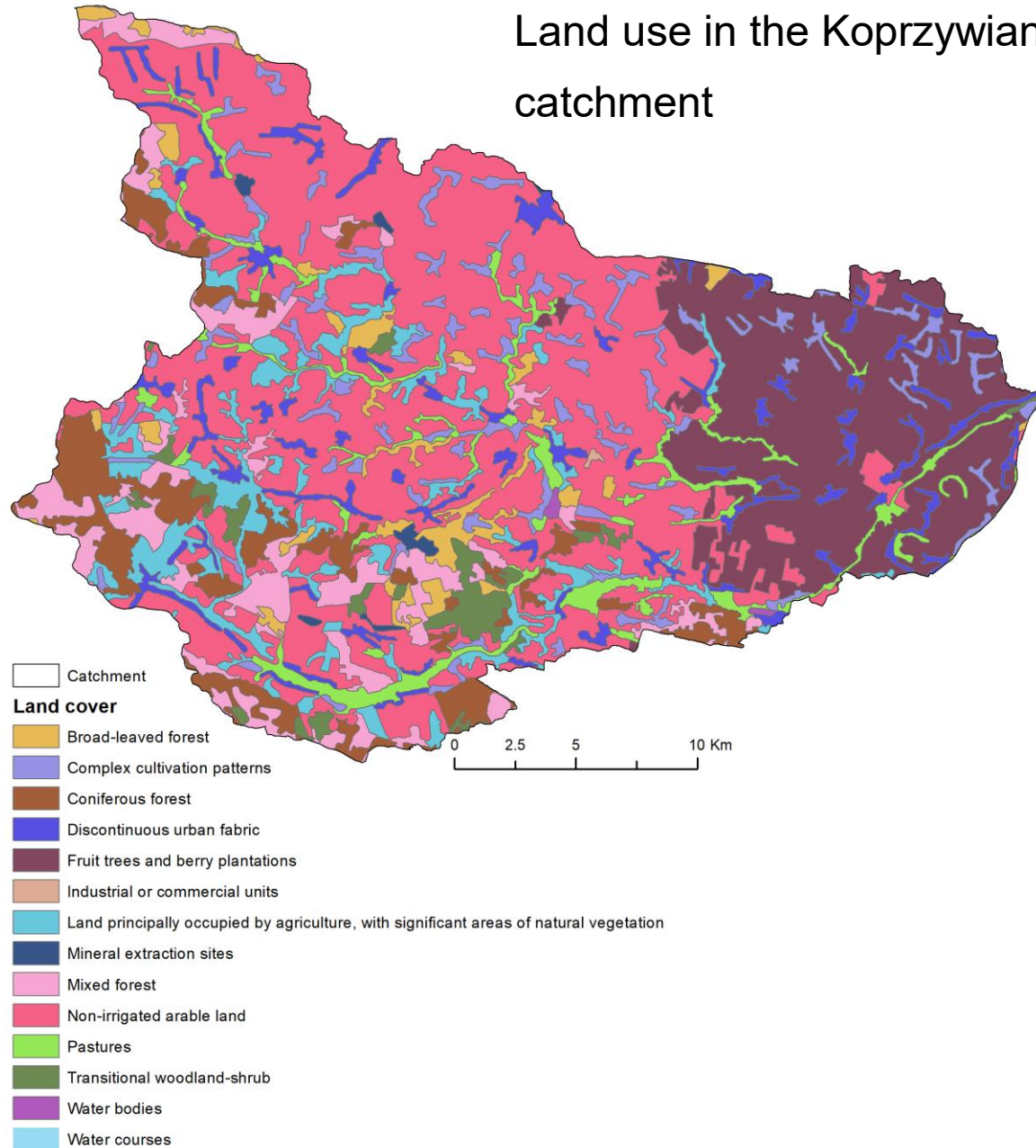
Cambisols

Fluvisols



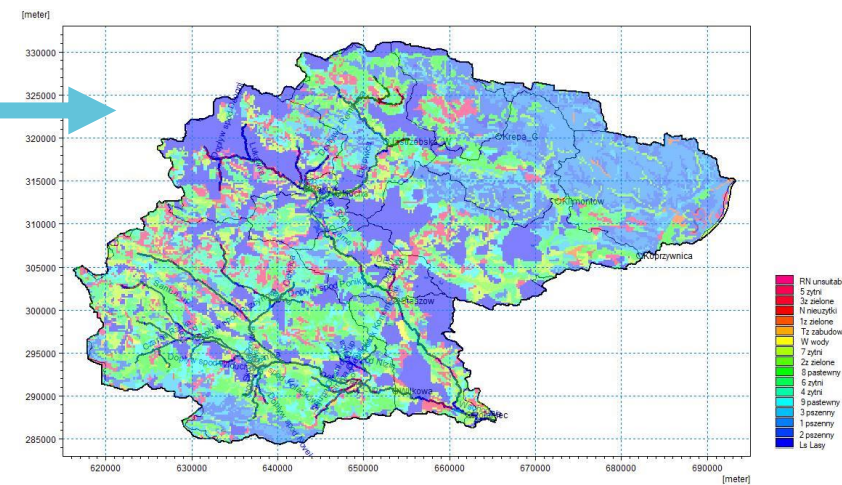
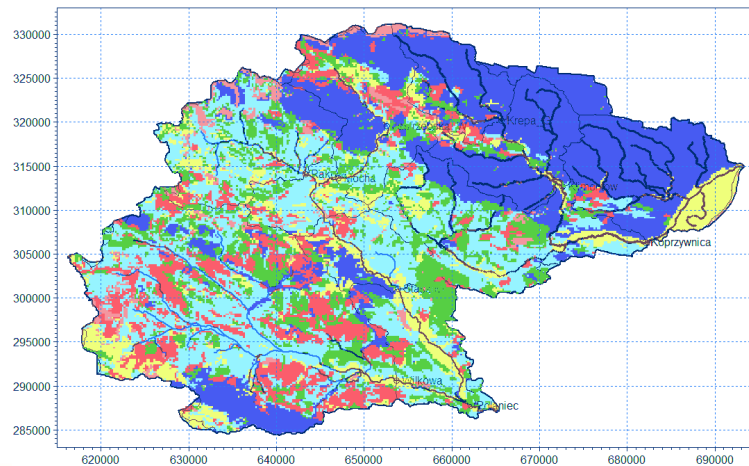
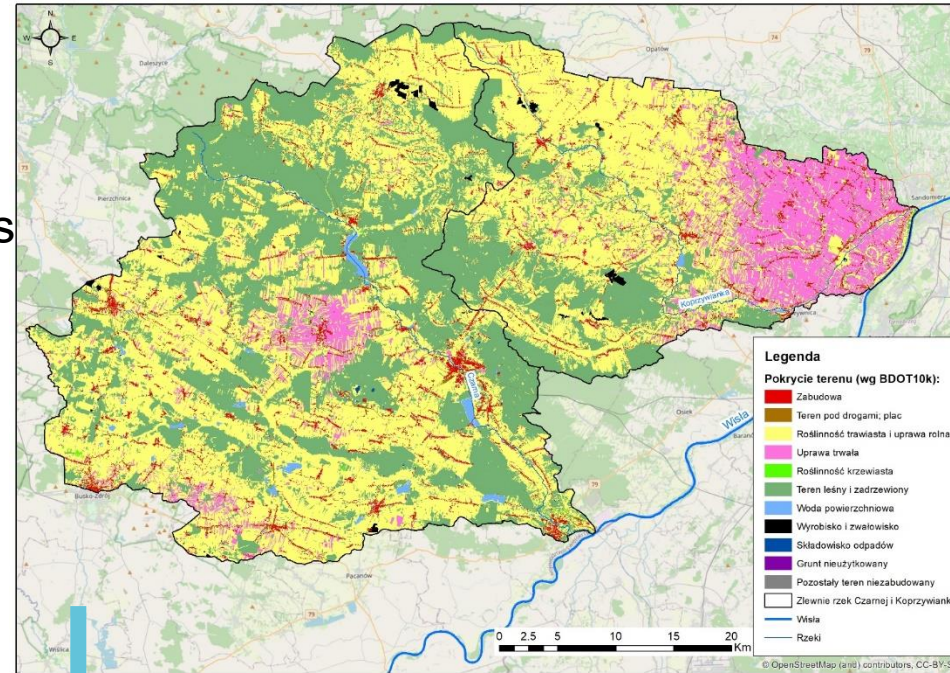
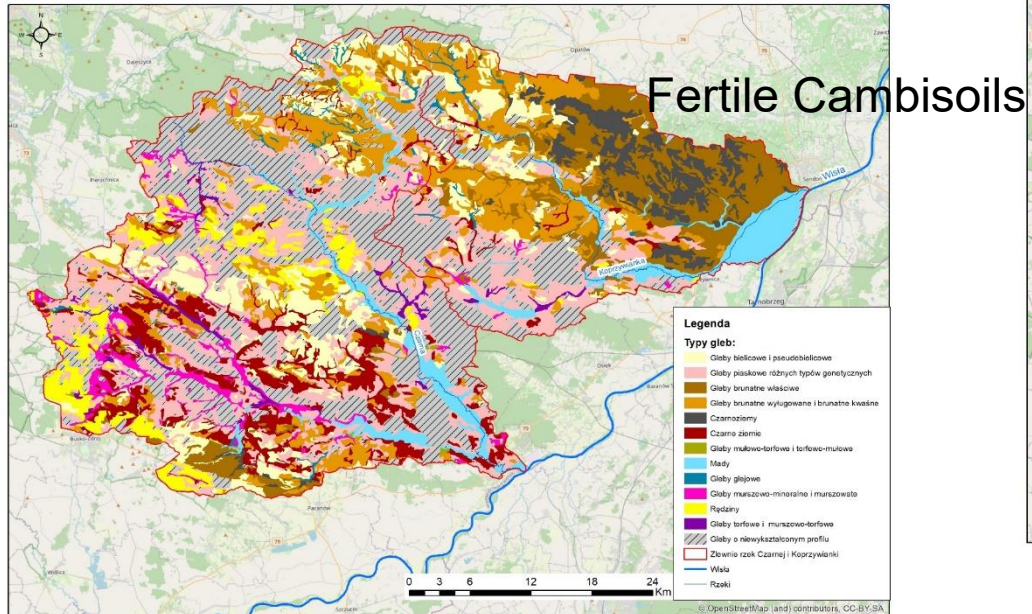


Land use in the Koprzywianka river catchment



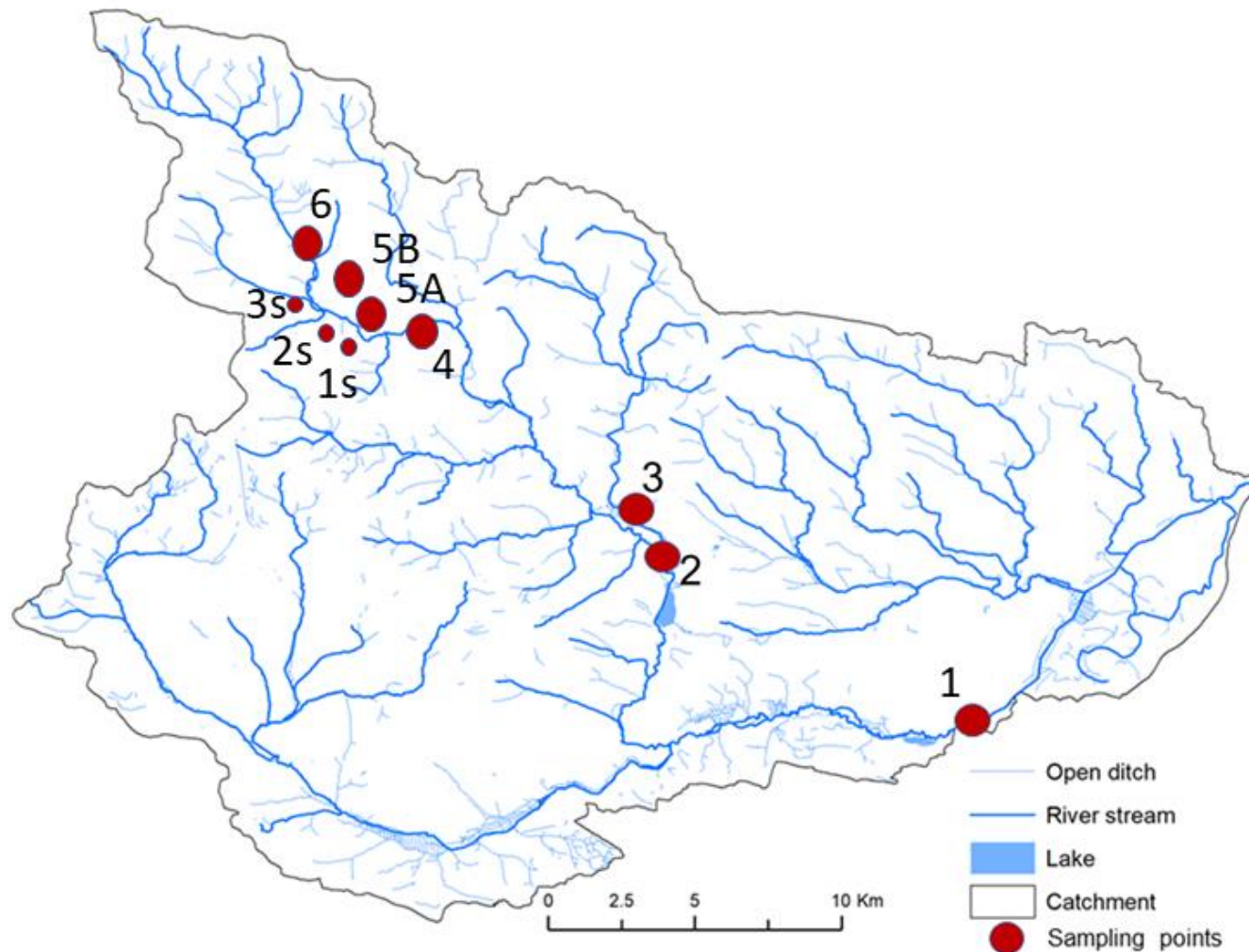


Soils and land use transferred into model parameters



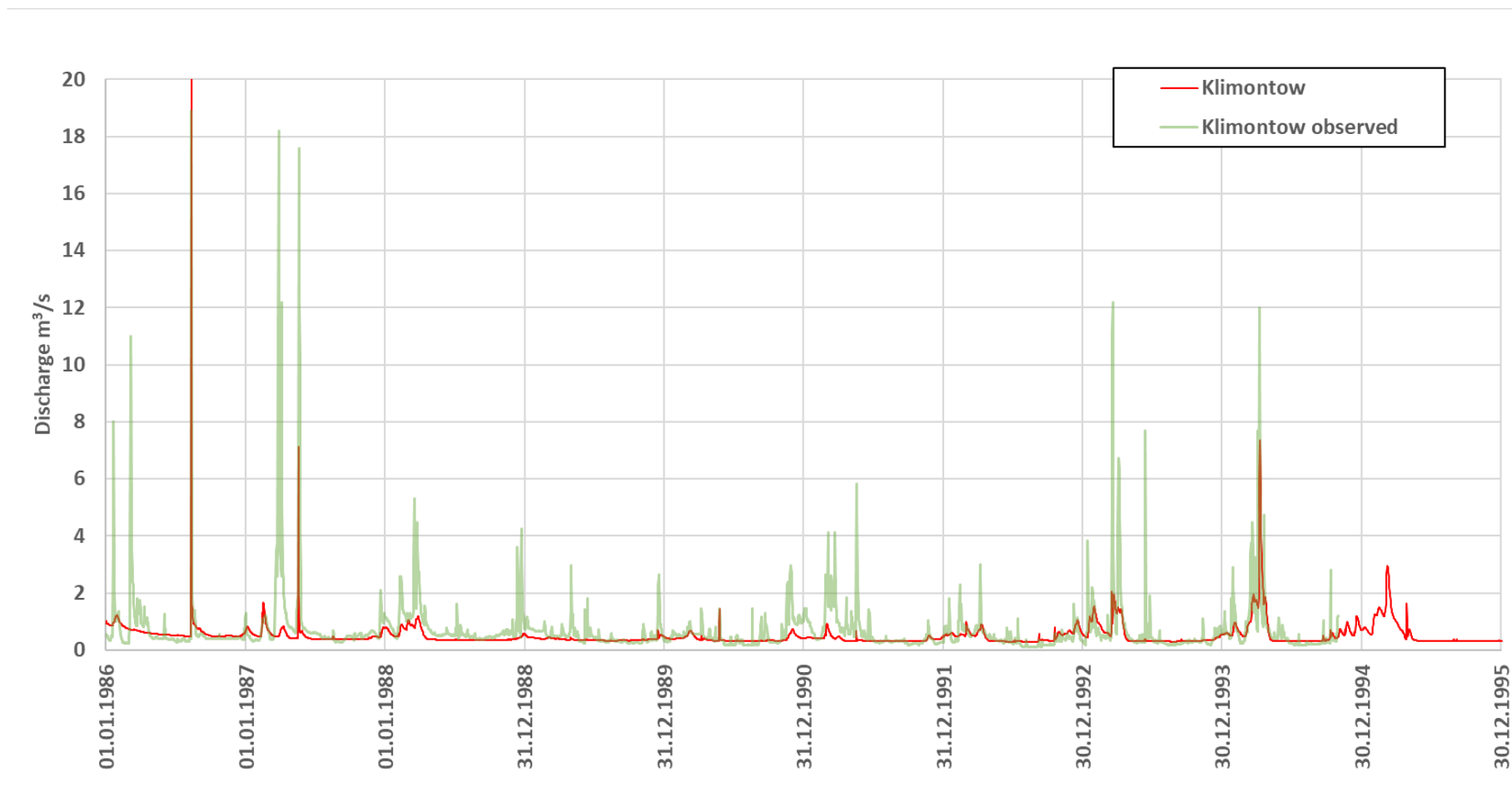


Soil and water sampling points in the Koprzywianka catchment (1,2,3 –water gauges)



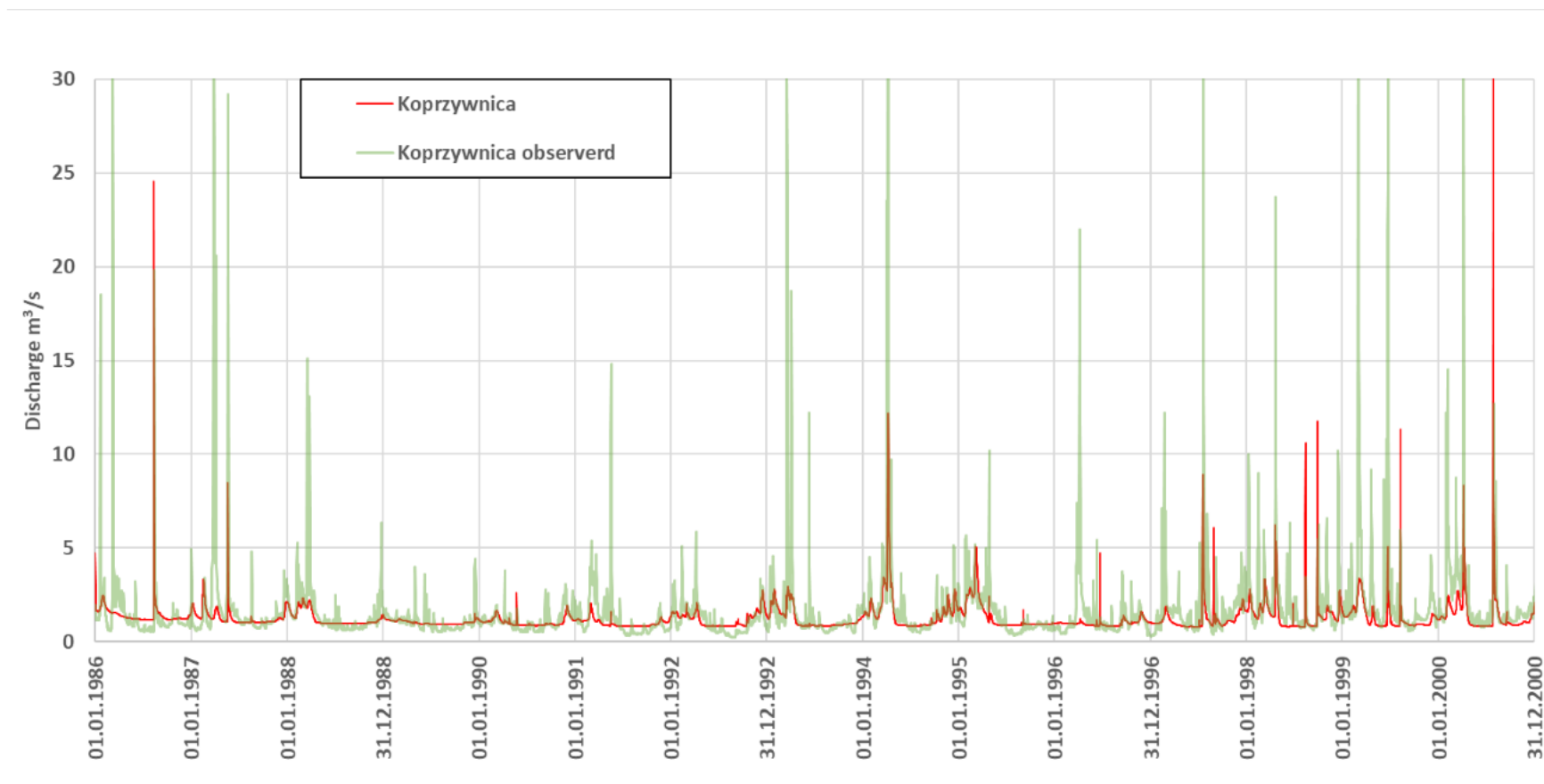


Comparisons of observed and modelled discharges of Koprzywianka at Klimontów





Comparisons of observed and modelled discharges of Koprzywnianka at Koprzywnica





Link to local/regional soil database?



- Data on soil types over Poland (for voivodships 1:5000 scale- geodata)
- Topsoil and subsoil texture
- Soil drought impact depth (water retention indicators)



Existing datasets

Table 1 Average concentrations of dissolved and total phosphorus at Koprzywnica (1) gauging station in the period 1991-2008

Year	Number of samples	Dissolved phosphorus PO_4^{3-}	Standard deviation	Maximum/ Minimum Concentration mg/l	Total phosphorus mgP/l	Standard deviation	Maximum/ Minimum concentration
1991	31	0,50	0,33	1,52/0,05	-	-	-
1992	52	0,39	0,27	1,95/0,09	-	-	-
1993	52	0,41	0,18	1,16/0,13	1,96	1,32	5,78/0,76
1994	49	0,50	0,28	1,29/0,14	1,26	0,43	2,06/0,56
1995	41	0,43	0,17	0,82/0,17	1,07	0,35	1,84/0,58
1998	7	0,30	0,17	0,45/0,18	0,30	0,44	0,68/0,09
1999	52	0,43	0,24	1,39/0,10	0,70	0,59	2,64/0,07
2000	43	0,39	0,09	0,69/0,20	0,69	0,49	1,68/0,18
2008	35	0,28	0,08	0,62/0,11	0,19	0,09	0,42/0,09



Table 4 Water quality indicators of Koprzywianka river for selected days on May 2025 (part 1)

date	sampling point	EC, microS/cm	TDS mg/L	TSS+TDS P tot, mg/L	TDS P tot, mg/L	TDS P- (PO4)3-, mg/L	TDS (PO4)3-, mg/L	TSS+TDS N tot, mg/L
09.05	1	552	353	0,111	0,048	0,06	0,19	0,896
	2	633	405	0,124	0,084	0,08	0,26	1,250
	3	777	497	0,073	0,047	0,05	0,15	0,851
13.05	1	552	353	0,124	0,083	0,07	0,22	0,808
	2	664	425	0,142	0,128	0,11	0,33	0,945
	3	778	498	0,071	0,045	0,05	0,15	0,854
17.05	1	556	356	0,129	0,075	0,05	0,16	0,784
	2	576	369	0,169	0,095	0,10	0,31	1,030
	3	788	504	0,109	0,069	0,07	0,2	0,912
21.05	1	540	346	0,438	0,07	0,08	0,23	0,966
	2	513	328	0,489	0,082	0,08	0,26	0,906
	3	522	334	0,320	0,074	0,07	0,22	0,899

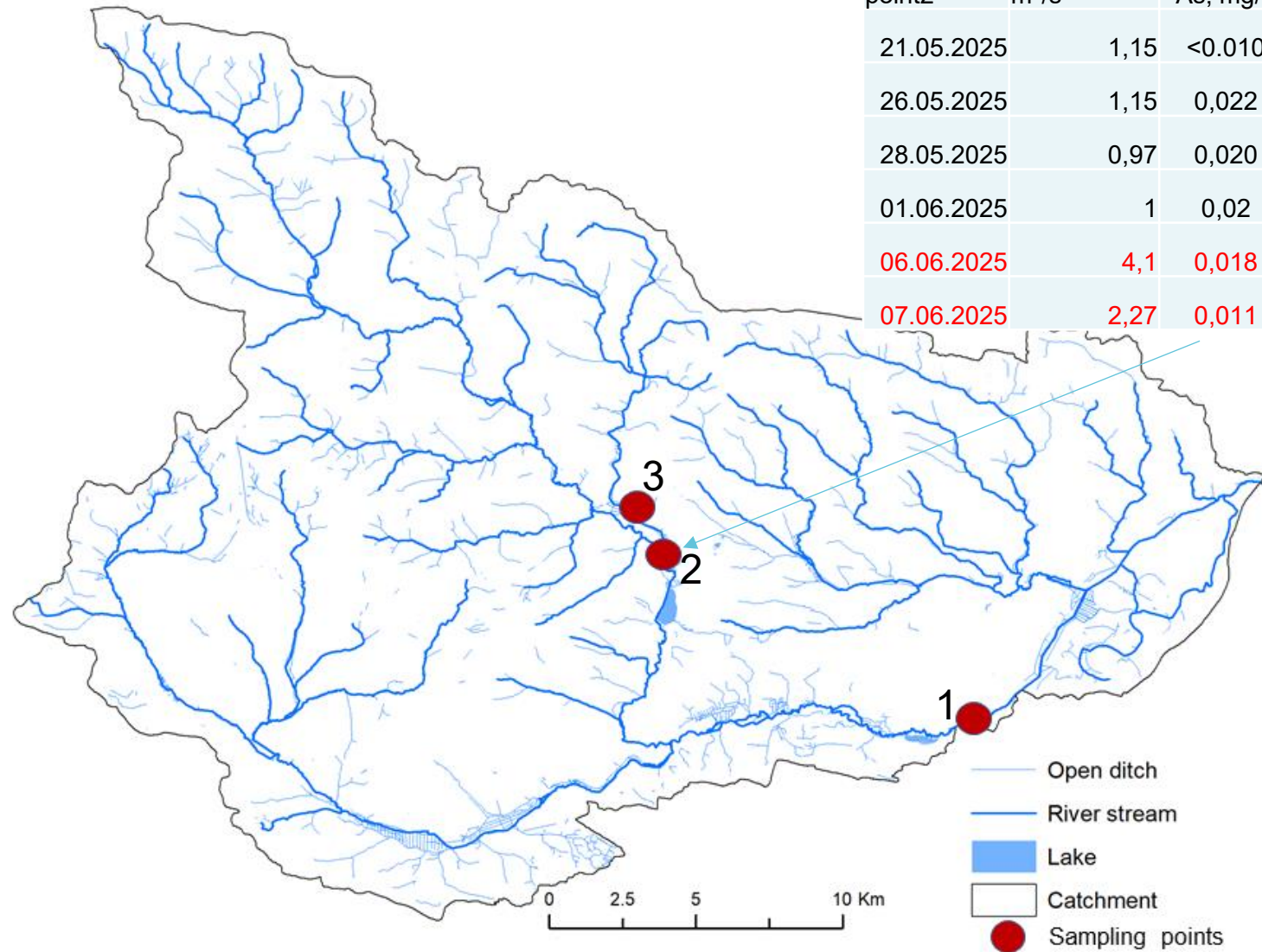


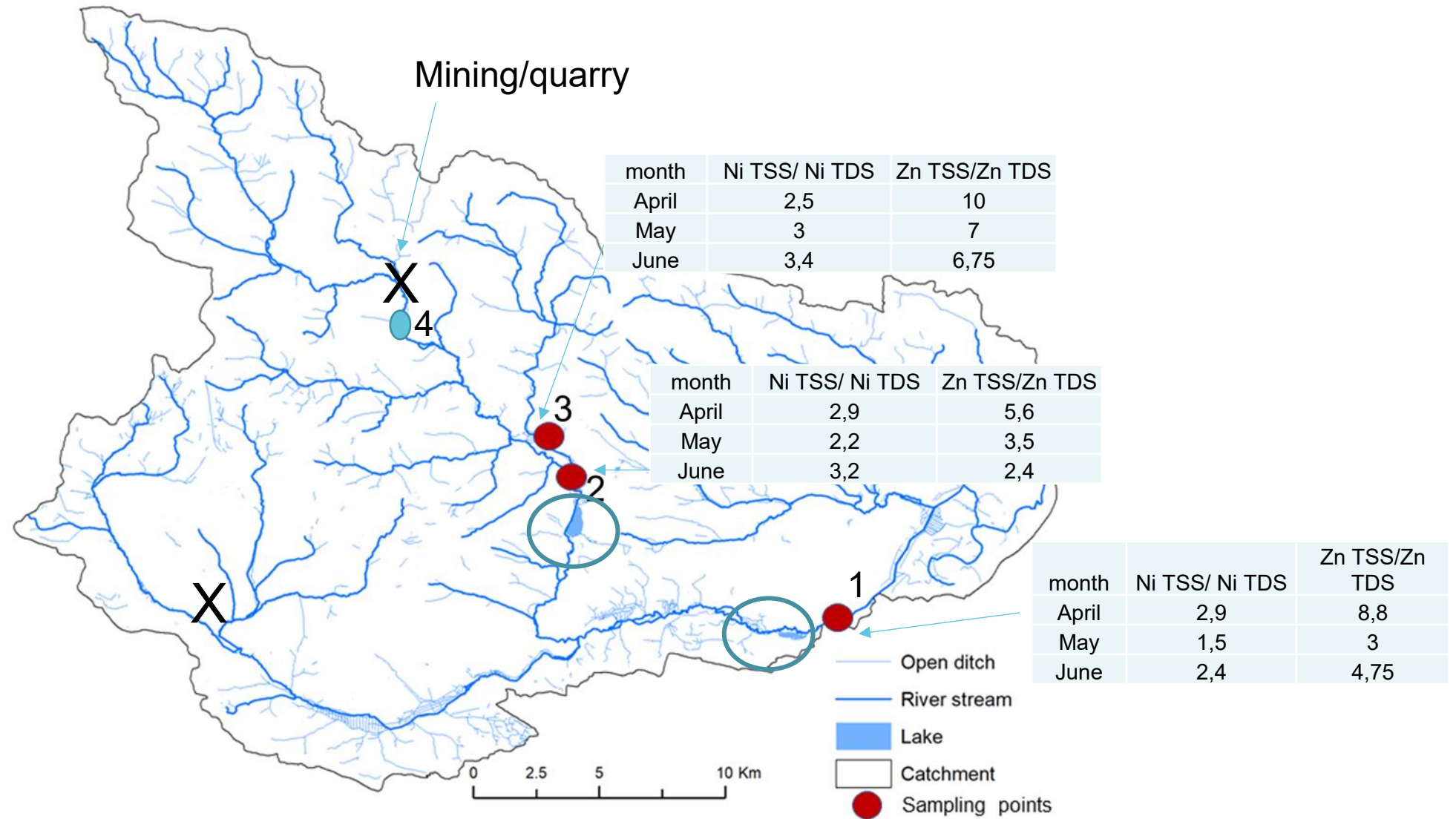
Table 6 Water quality indicators of Koprzywianka river for selected days on May 2025

date	sampling point	TSS+TDS Pb, mg/L	TDS Pb, mg/L	TSS+TDS As, mg/L	TDS As, mg/L	TSS+TDS Ni, mg/L	TDS Ni, mg/L
09.05	1	<0.010	<0.010	<0.010	<0.010	0,015	0,013
	2	<0.010	<0.010	<0.010	<0.010	0,013	0,014
	3	<0.010	<0.010	0,016	<0.010	0,013	0,012
13.05	1	<0.010	<0.010	<0.010	<0.010	0,016	0,014
	2	<0.010	<0.010	0,022	<0.010	0,013	0,014
	3	0,012	<0.010	0,011	0,012	0,016	0,013
17.05	1	<0.010	<0.010	0,013	<0.010	0,013	0,012
	2	<0.010	0,011	0,020	<0.010	0,022	0,015
	3	0,012	<0.010	0,013	<0.010	0,020	0,012
21.05	1	<0.010	<0.010	0,016	<0.010	0,051	0,014
	2	<0.010	<0.010	0,018	<0.010	0,080	0,014
	3	<0.010	<0.010	0,022	<0.010	0,062	0,014



		TSS+TDS	TDS	TSS+TDS	TDS	TSS+TDS	TDS	TSS+TDS	TDS
point2	flow rate m³/s	As, mg/L	As, mg/L	Ni, mg/L	Ni, mg/L	Zn, mg/L	Zn, mg/L	Cr, mg/L	Cr, mg/L
21.05.2025	1,15	<0.010	<0.010	0,013	0,014	0,100	0,036	<0.005	<0.005
26.05.2025	1,15	0,022	<0.010	0,013	0,014	0,091	0,042	<0.005	<0.005
28.05.2025	0,97	0,020	<0.010	0,022	0,015	0,133	0,045	<0.005	<0.005
01.06.2025	1	0,02	<0.01	0,032	0,016	0,096	0,033	<0.005	<0.005
06.06.2025	4,1	0,018	<0.010	0,080	0,014	0,453	0,012	0,016	<0.005
07.06.2025	2,27	0,011	<0.01	0,045	0,014	0,234	0,017	<0.005	<0.005





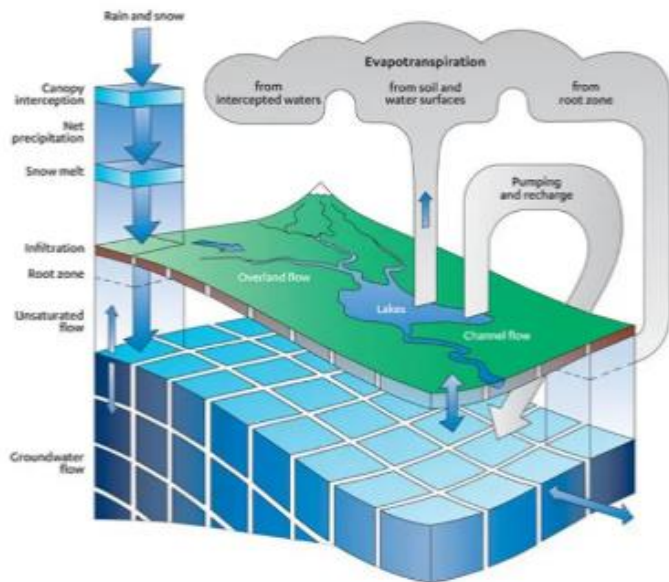




Model trains



MIKE-SHE + **Eco-lab**



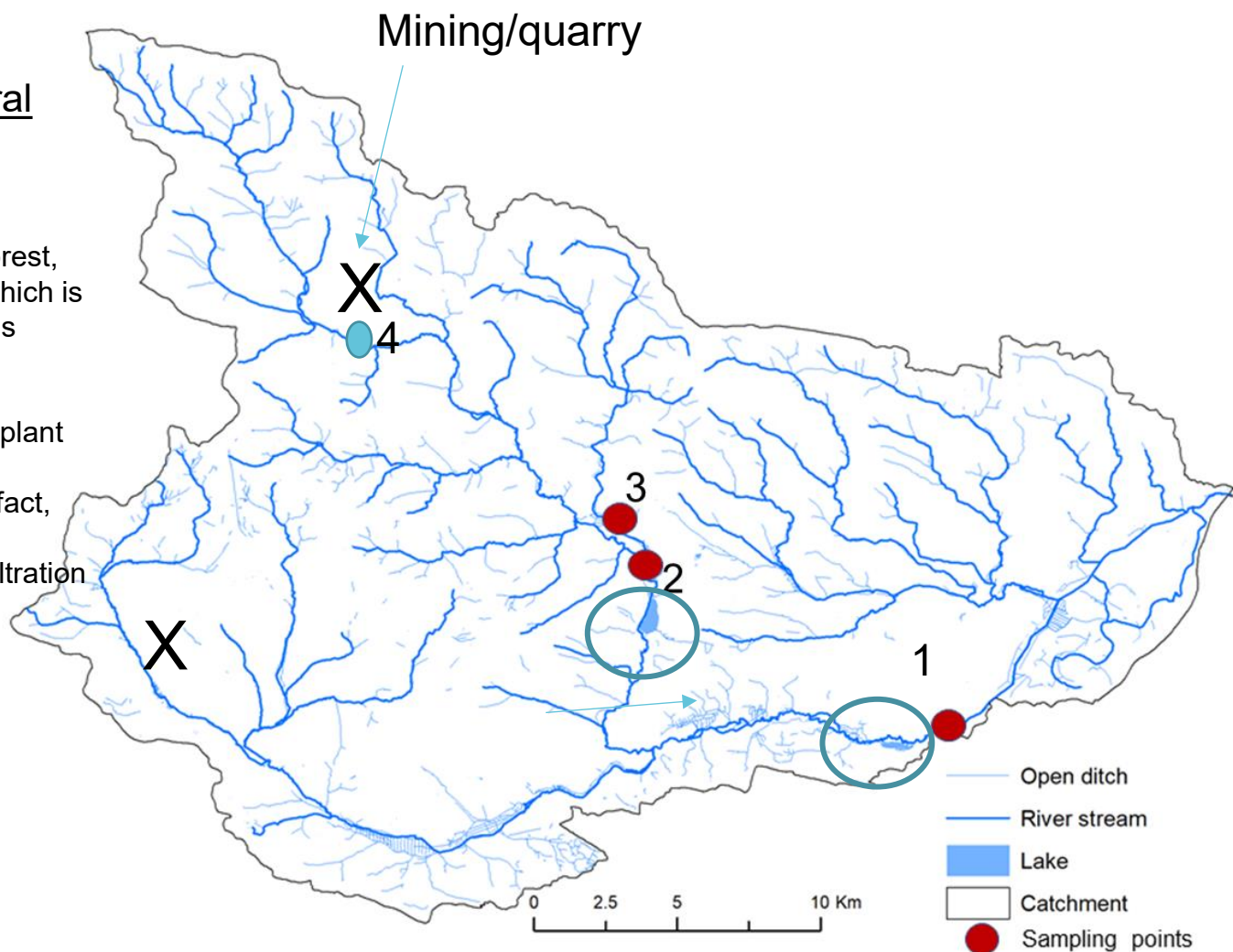
- metals in subsurface flow
- sediment retention in water reservoirs



Retention of nutrients in reservoirs and sediment trap efficiency -model simplifications for reservoir retention of Phosphorus in particular, outline of related modelling complexities

Spatial reduction in agricultural activity

1) replacement with spontaneous, unmanaged meadows and gradually forest, the abandonment of agricultural lands which is likely in the Koprzywianka basin. = This deals with changes in areal evapotranspiration and plant species composition (slow, gradual changes in plant communities- new potential evapotranspiration assumed) and , in fact, no fertilizer dosage. This may lead to decreased surface runoff and more infiltration

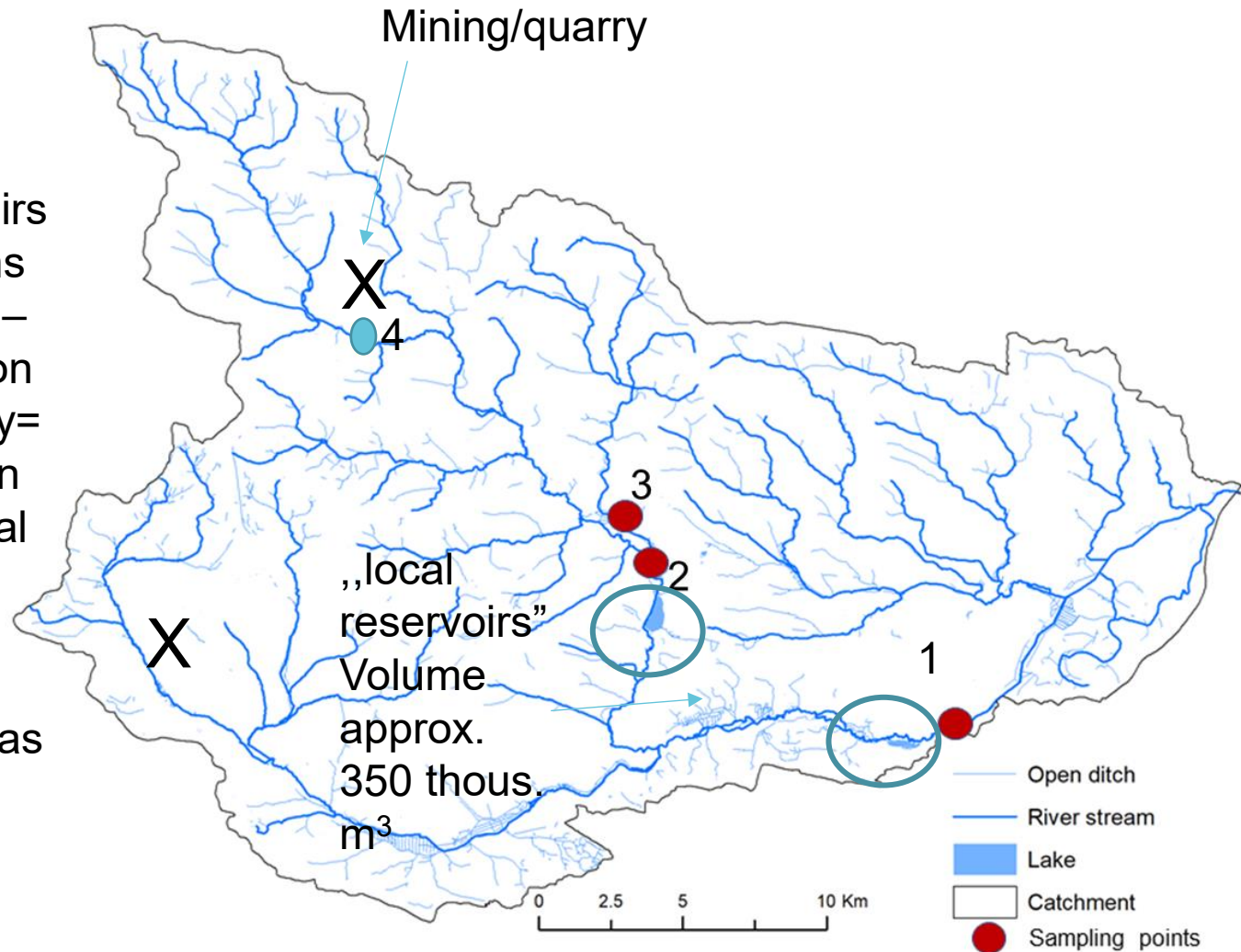




Retention of nutrients in reservoirs and sediment trap efficiency -model simplifications for reservoir retention of Phosphorus in particular, outline of related modelling complexities

Needs for Mike1 D coupling and possible erosion simulations:

- Simulation of reservoirs as river cross-sections of a reservoirs' width – in a wide cross-section the velocity practically= 0, and sedimentation occurs (1 dimensional model- laborious?)
- Simulation as a reservoir – setting a reservoirs physically as a structure with inlet and outlet= also flow velocity goes to 0

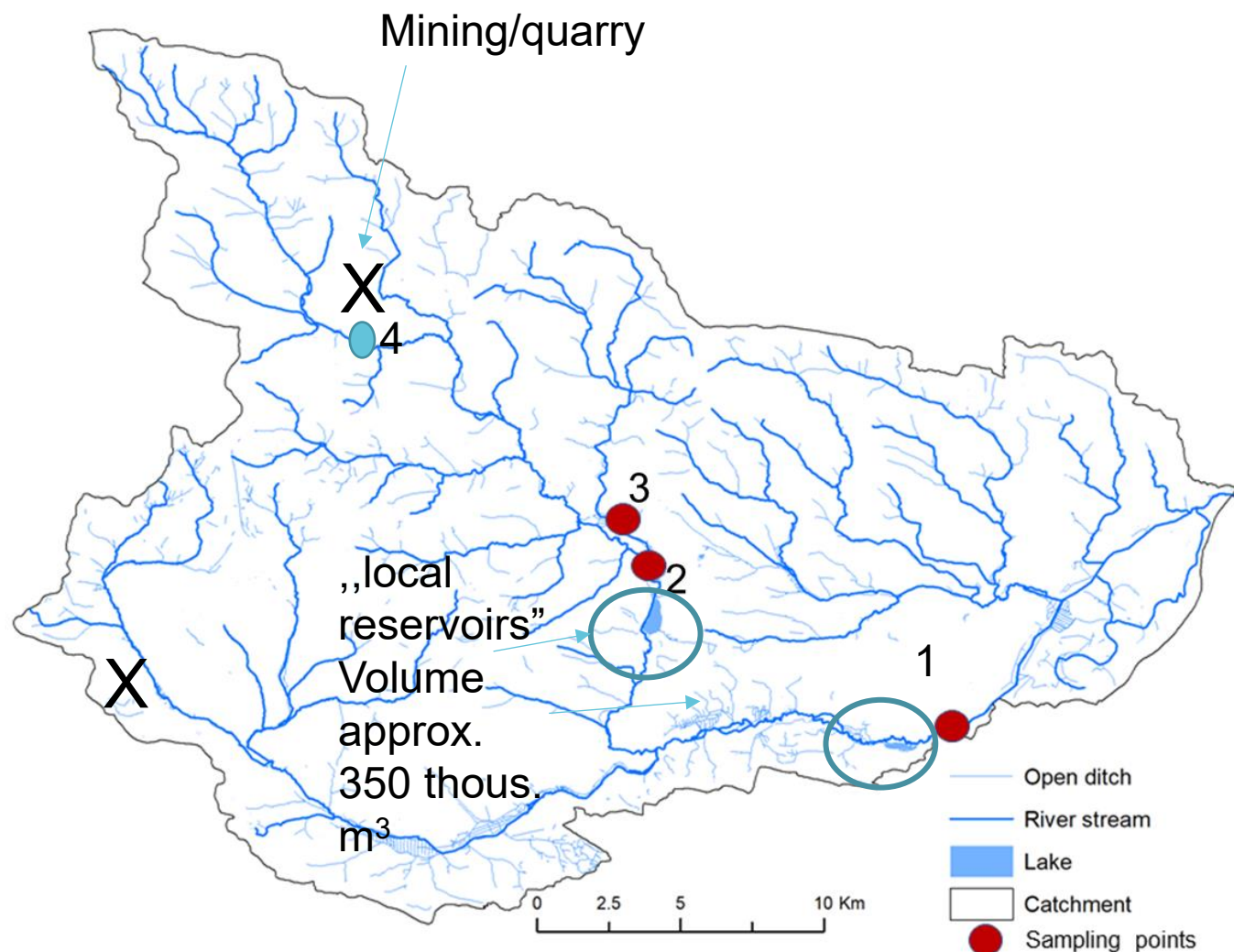




Retention of nutrients in reservoirs and sediment trap efficiency -model simplifications for reservoir retention of Phosphorus in particular, outline of related modelling complexities, Increased water retention through modification of streams, and development of retention basins and wetlands

Needs for Mike1 D coupling:

- In conclusion, all the sediment remains in the reservoir,
- Impact on Phosphorus retention: complex impacts of the vegetation etc. on P reduction capabilities
- Alternative= simplification : amount of stored sediment* enrichment coefficient = P reduction



Heavy metals sources



Water

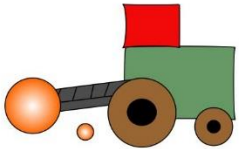


Soil

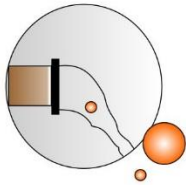


Air

fertilizers,
pesticides



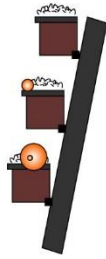
sewage
contains HMs



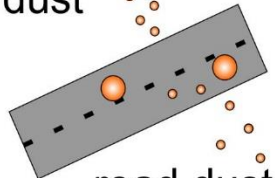
desposal of
lead acid
batteries



mining

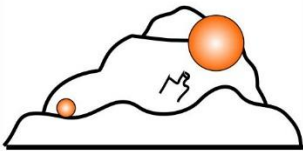


atmospheric
dust

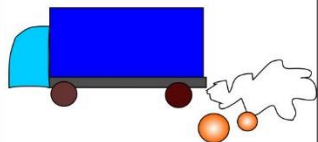


road dust

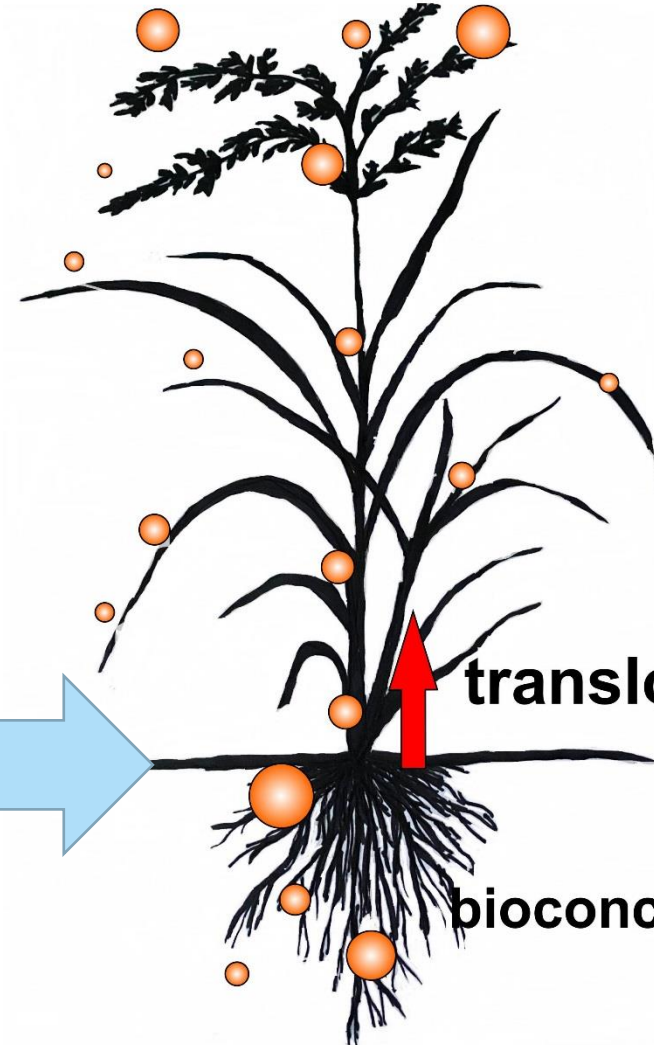
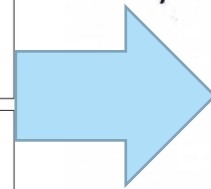
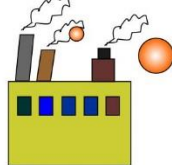
urban
solid
wastes



exhausts
of automobiles



factory
chimneys



translocation

bioconcentration



Root Concentration Factor, Shoot Concentration Factor and Translocation Factor are important parameters to characterize the accumulation capacity of plants for chemicals under different conditions.

Root Concentration Factor (RCF)

Calculated as the ratio between the mean compound concentration measured in roots (C_R expressed as ng of compound per g of root dry weight) and the mean compound concentration measured in the corresponding standard soil samples (C_{soil} expressed as ng of compound per g of dry soil) (Hu et al., 2021):

$$RCF = \frac{C_R \text{ (ng g}^{-1} \text{ dw)}}{C_{soil} \text{ (ng g}^{-1} \text{ dw)}}$$





The ***shoot concentration factor (SCF)*** was calculated as the ratio between the mean compound concentration measured in the shoots (C_s expressed as ng of compound per g of root dry weight) and C_{soil} (Gao and Zhu, 2004):

$$SCF = \frac{C_s \text{ (ng g}^{-1} \text{ dw)}}{C_{soil} \text{ (ng g}^{-1} \text{ dw)}}$$





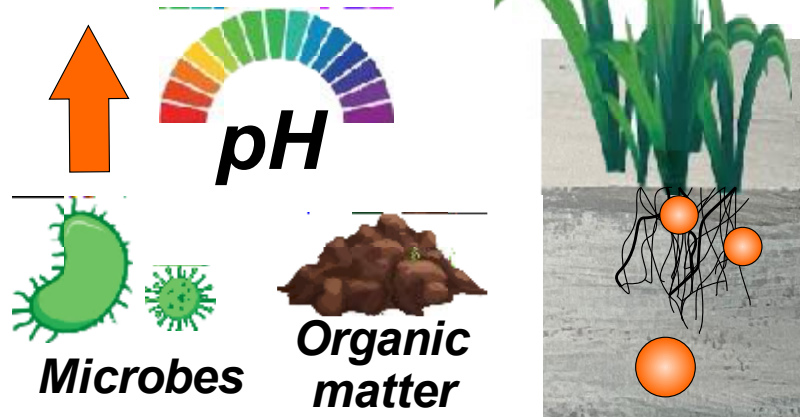
The ***translocation factor (TF)*** was calculated as the ratio between the SCF and the RCF (Hu et al., 2021)

$$TF = \frac{SCF}{RCF} = \frac{C_S (ng\ g^{-1}\ dw)}{C_R (ng\ g^{-1}\ dw)}$$





Uptake by roots

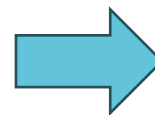
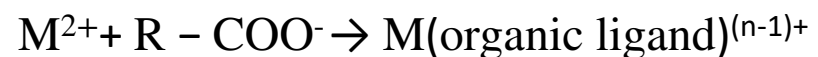


Movement to shoots and leaves

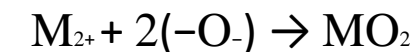


Mechanisms of PTE stabilization in soil with organic matter:

Compost, rich in organic matter such as humic and fulvic acids, binds heavy metals (e.g., Pb, Zn, Cd, Cu) via complexation and chelation, forming stable organic-metal complexes that are less bioavailable and mobile:



At alkaline pH, the phenolic group loses a proton, forming a negatively charged phenoxide ion ($-O^-$), which is highly reactive and can interact with PTE cations:



A potential for modeling tools (e.g. Ecolab) to take pH and other related factors into account (organic matter content) in phytostabilization studies



	Measures													
	No measures	Spatial reduction in agricultural activity	Shift to conservation agriculture	Shift to no-till agriculture	Permament soil organic cover	Reduce chemical fertilizer	Crop rotation and diversification (more legumes)	Decrease pesticide usage	Increased water retention through modification of streams, and development of retention basins and wetlands	Increased water retention through modification of streams, and development of retention basins and wetlands x Shift to conservational agriculture	Increased water retention through modification of streams, and development of retention basins and wetlands x Spatial reduction in agricultural activity	Sludge recycling and deposition on soil	Reducing atmospheric emissions	
Baseline (curent situation)	x	x	x	x	x	x	x	x	x	x	x	x	x	
Climate scenario SSP1-2.6	x	x	x	o	o	o	o	o	x	o	o	x	o	
Climate scenario SSP5-8.5	x	x	x	o	o	o	o	o	x	o	o	x	o	

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