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Discharge of groundwater-borne phosphorus into a lake and its spatial variability

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The quantification of lacustrine groundwater discharge (LGD) in water and nutrient budgets of lakes is challenging and thus often neglected. However, by carrying large nutrient loads, groundwater might play a key role in a lake′s nutrient budget even when its contribution to the water balance is small. In the present study, we quantify the total annual LGD by the calculation of annual groundwater recharge in the subsurface catchment of Lake Arendsee in northern Germany. Furthermore, spatial variability of LGD with varying phosphorus concentrations is expected to have significant influence on the nutrient budget of that lake. To assess the spatial variability, LGD is calculated based on temperature depth profiles of the lake sediment along the shoreline. The combination of total LGD and spatial LGD patterns allows calculating LGD volumes for single shoreline sub-sections. These calculations reveal that a large portion of the total LGD enters the lake within a relatively limited section of the shoreline. Furthermore, groundwater phosphorus concentrations along the shoreline are assigned to the sub-sections to calculate phosphorus loads. Since nutrient concentrations differ strongly, groundwater-borne phosphorus loads vary to a large extent between the sub-sections. This study demonstrates the importance of (1) total LGD quantity, (2) spatial LGD patterns, and (3) heterogeneous groundwater nutrient concentrations for a reliable determination of groundwater-borne nutrient loads.