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Permafrost conditions in peatlands govern riverine flushing of dissolved organic carbon, methylmercury, and nutrients

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Abstract. Permafrost thaw and intensified droughts and floods threaten to alter the mobilization of dissolved organic carbon (DOC), nutrients and methylmercury (MeHg) from boreal peatlands, with cascading impacts on aquatic ecosystem functions and traditional food sources. Here we monitored 27 peatland-dominated (>30%) catchments in western Canada (150 to 52,000 km2) over a five-year period (2020 – 2024) which captured extreme hydroclimatic conditions. These catchments spanned a climatic and permafrost gradient (mean annual temperature -0.2 to -2.8°C), which provided a space-for-time framework to assess impacts of continued thaw and warming. Our results demonstrated that catchment climate, and thus permafrost conditions, strongly controlled the hydrological response of solute concentrations. Warmer catchments showed a pronounced flushing response where DOC and MeHg concentrations increased by 50% and 80%, respectively, as discharge increased from the 10th to 90th percentile. In contrast, colder catchments maintained a chemostatic response, where concentrations remained stable and low despite hydrological variability. Similar climate-hydrology interactions were found for total nitrogen, total phosphorous, and inorganic phosphorous, but not for inorganic nitrogen. It is likely that permafrost conditions in peatlands affect both the production of solutes and their hydrological connectivity to the stream network. The presence of permafrost in peatlands may act to both ensure connectivity during droughts but also preclude full connectivity during floods, yielding the observed patterns. Our findings suggest that ongoing peatland permafrost thaw will increase mobilization MeHg, DOC, and nutrients during high flow periods. This shift necessitates further monitoring to understand the long-term consequences for aquatic ecosystems and northern communities.

Keywords. Permafrost thaw; peatlands; hydrological flushing; methylmercury; dissolved organic carbon; climate change

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1. Introduction

Boreal peatlands are dominant landscape sources of dissolved organic carbon (DOC), nutrients, and methylmercury (MeHg) to aquatic ecosystems, but downstream mobilization may depend critically on permafrost conditions which alter both hydrological connectivity and biogeochemistry of peatlands (Connon et al., 2014; Gordon et al., 2016; Prijac et al., 2023). Increased concentrations and export of these solutes risk detrimental effects on downstream high-latitude aquatic ecosystems, including brownification of waters (Kritzberg et al., 2019), eutrophication (Ayala-Borda et al., 2021), and increased supply of MeHg to aquatic food webs (Gantner et al., 2010). As a potent neurotoxin that often is co-transported with DOC, MeHg can bioaccumulate and biomagnify in aquatic food webs to levels that threaten the safety of country foods, such as fish, and the health of northern communities (Aggarwal et al., 2014; Houde et al., 2022). However, mobilization of solutes often depends on hydrological conditions, and therefore, understanding how permafrost conditions influence solute export during both drought and flood conditions is essential for predicting how thaw may shift northern water quality.

Catchment characteristics often exert a strong control over concentration–discharge (C-Q) behaviour in rivers, determining whether downstream solute mobilization is primarily production or transport limited (Godsey et al., 2009; Rose et al., 2018; Wagner et al., 2019). In permafrost-free regions, peatlands and upland forests often exhibit opposing C-Q behaviours for DOC. Upland forests typically show a "flushing" DOC response (i.e. transport limitation), where wet conditions activate runoff through shallow, organic-rich soil horizons which cause elevated stream DOC concentrations (Laudon et al., 2011; Moatar et al., 2017; Rose et al., 2018). In contrast, deep organic peatland soils generally remain connected to streams across hydrological conditions, resulting in DOC dilution during periods of high streamflow (i.e. production limitation) (Schiff et al., 1998; Gomez-Gener et al., 2021). However, in western Canada where peatlands exist in a subhumid climate, it has been observed that peatlands can become hydrologically disconnected during extended droughts, leading to lower stream DOC concentrations (Orlova, 2024). The presence of permafrost in peatlands may shift the DOC C-Q relationship by either changing DOC production rates (as dependent on soil temperature and anaerobic conditions) or by restricting near-surface groundwater connectivity to stream networks (Wright et al., 2022).

While MeHg is often co-transported with DOC in peatland-dominated catchments (Kirk and St Louis 2009), the production of MeHg is associated with biogeochemical hotspots and thus its C-Q behaviour in streams may diverge from that of DOC (Mitchell et al., 2009). The microbial production of MeHg from atmospherically deposited mercury (Hg) varies both by peat depth and among peatland types as it is facilitated by anaerobic conditions and the availability of both labile organic carbon and terminal electron acceptors such as sulfate and ferrous iron (Mitchell et al., 2008). Similarly, mobilization of inorganic nutrients, such as ammonia (NH_4^+), nitrate (NO_3^-), and phosphate (PO_4^{3-}), depend on hotspots for both nutrient mineralization and nutrient uptake, which has led to variable C-Q relationships among studied regions (Bieroza et al., 2018; Pardo et al., 2022). Permafrost thaw alters peatland hydrology and shifts the relative abundance of different peatland types

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(e.g. bogs and fens) which thus may affect the overall peatland capacity for production and mobilization of both MeHg and nutrients (Thompson et al., 2025).

Catchment size can modulate C-Q relationships in several ways. Larger catchments integrate C-Q relationships of heterogeneous land covers and water with different residence times, often leading toward chemostasis (Ensign & Doyle, 2006; Moatar et al., 2017). However, the role of within-stream processes of bank erosion and bed-sediment resuspension become increasingly importance in larger rivers and at high flow for some water quality parameters. Many compounds bind to fine sediments, including phosphorous and Hg for which particle-bound export can be dominant (Julian et al., 2008; Riscassi et al., 2011). Consequently, when evaluating the specific impacts of peatland permafrost on stream chemistry, it is necessary to differentiate between terrestrial mobilization and the catchment scale-dependent effects of sediment transport and in-stream processing.

The Taiga Plains of western Canada, a major northern peatland region, has a ~40% peatland cover and spans a broad permafrost gradient (Olefeldt et al., 2021). The region has some of the most rapid rates of climate warming which is causing widespread permafrost thaw (Carpino et al., 2021) and has also had increasing hydroclimatic variability with recent extreme droughts and floods (Hinzman et al., 2005; Previdi et al., 2021; Stankevicius et al., 2025). In the discontinuous permafrost zone, peatland complexes are a fine-scale mosaic of permafrost-affected peat plateaus and non-permafrost bogs and fens, each with characteristic hydrological functions and biogeochemical conditions (Quinton et al., 2009; Connon et al., 2014). Permafrost has the capacity to limit the production of solutes, sequester solutes for decades, and disrupt flow pathways limiting transportation capabilities for both MeHg and DOC in northern ecosystems (Connon et al., 2014; Wright et al., 2022; Thompson et al., 2023a; Shewan, 2024; Gindorf et al., 2025). Peat plateaus are elevated, and their relatively dry conditions are associated with low potential for MeHg production (Gordon et al., 2016). Ongoing permafrost thaw and peat plateau collapse leads the lateral expansion of non-permafrost fens which act as headwater drainage networks and the connection of previously isolated non-permafrost bogs, effectively increasing the runoff-contributing peatland area (Connon et al. 2015). Anaerobic conditions in non-permafrost bogs and fens promote MeHg production, especially in fens with alkaline groundwater and higher concentrations of sulfate (Thompson et al., 2025). While concentrations of DOC and MeHg in rivers of peatland-rich catchments are known to generally decrease with increasing permafrost extent (Frey & Smith, 2005; Olefeldt et al., 2014; Shewan, 2024), it remains unclear how permafrost conditions control the sensitivity of DOC, MeHg, and nutrient mobilization during extreme droughts and floods.

This study aimed to assess the influence of permafrost conditions, using climate as a proxy (mean annual temperature [MAT]), on solute mobilization under contrasting wet and dry hydrological conditions on the peatland-rich Taiga Plains of western boreal Canada. We focused on solutes which are associated with peatlands (DOC, MeHg, nutrients) and which are of community concerns due to potential impacts from permafrost thaw on brownification, eutrophication and Hg

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biomagnification in food webs. By sampling 27 rivers across a permafrost gradient, we employed a space-for-time approach to gain an understanding of potential impacts of continued permafrost thaw which will inform future water resource management and land use.

2. Methods

2.1 Study area and catchment characteristics

Water chemistry samples were collected from 27 creeks and rivers in northwestern Alberta, and the southern Northwest Territories in the Taiga Plains ecozone in Canada during the open water season from 2020 – 2024 (Figure 1; Table 1). The sites were sampled between 5 and 25 times, depending on site accessibility (e.g., wildfires restricting access, road conditions, etc.). All 27 catchments had a minimum peatland cover of 30% (Ecosystem Classification Group, 2009). There was extreme variability in hydrological conditions during the sampling period, capturing the wettest and driest periods on record (Table 1). Catchment size ranged from 130 km^2 to 50,000 km^2 to capture the different types of streams in the region, with seven sampling locations at the larger rivers in the region (Hay River [3 locations], Kakisa, Sambaa Deh, Chinchaga, and Buffalo Rivers with catchment sizes > 10,000 km^2). Several of the sampling locations were identified by local collaborators, community members, and Indigenous leaders as being of community interest.

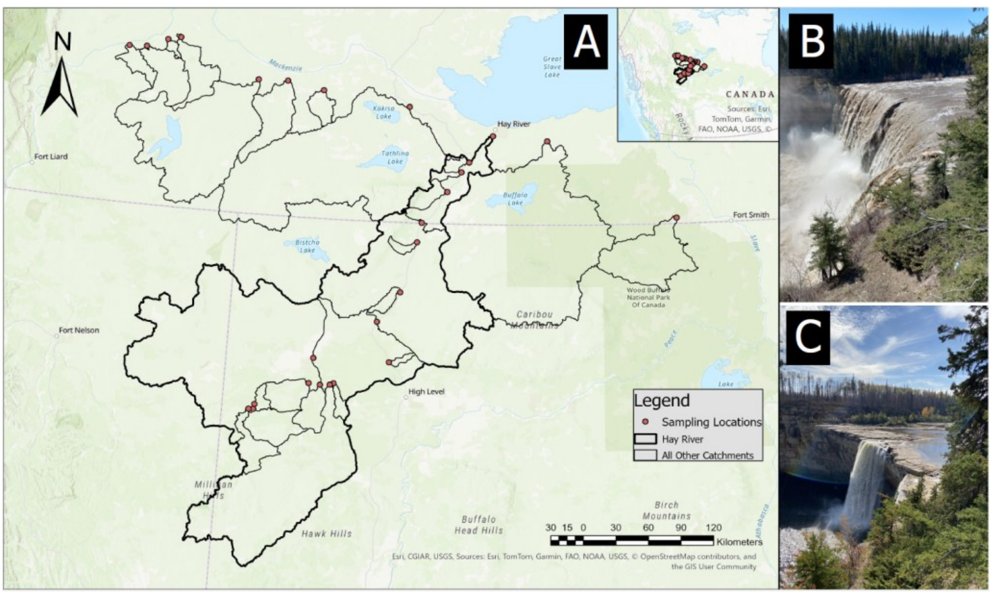

Figure 1. A) Map of the 27 stream sampling locations, along with outlines of their catchments. The Hay River catchment was the only river with subcatchment sampling; its catchment is in bold. B) Image of Alexandra Falls, Hay River, NT in May 2022 during extremely high flow conditions. C) Image of Alexandra Falls at the same location in September 2024 during extremely low flow conditions. Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS. Powered by Esri.

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Table 1. Catchment characteristics for rivers sampled in this project, including sampling location, catchment size, catchment climate, and peatland extent. Flow Percentile Range (FPR) shows the range of flow conditions for sampling occasions at each site. Most sites were sampled from June 2020 – September 2024, with exceptions at H011 and H034 which were sampled from August 2022 onwards.

ID	Site Name	Long	Lat	Area (km^2)	MAT (°C)	Percent Peatland	FPR (%)	Sampling Occasions (n)
H002	Hay River in Hay River	60.75	-115.82	52,000	-0.89	41	5 – 99	25
H003	Escarpment Creek	60.53	-116.22	215	-2.12	63	4 – 99	24
H004	Mink Creek	60.44	-116.34	187	-2.12	62	4 – 96	7
H006	Swede Creek	60.27	-116.57	526	-2.40	38	2 – 94	15
H011	Hay River at 60th Parallel	60.00	-116.97	46,200	-0.81	43	4 – 55	10
H013	Camp Creek	59.84	-117.04	193	-1.83	47	14 – 96	5
H022	Lutose Creek	59.41	-117.28	296	-1.13	51	2 – 94	23
H023	Hay River near Meander River	59.15	-117.64	37,500	-0.54	38	9 – 96	11
H034	Hay-Zama Wetland Outflow	58.81	-118.62	21,200	-0.65	41	6 – 68	16
H043	White Muskrat Creek	58.39	-119.49	243	-0.69	37	6 – 93	16
H044	Unnamed River S. of Rainbow Lake	58.35	-119.51	1340	-0.66	42	6 – 66	9
H045	Hay River S. of Rainbow Lake	58.35	-119.58	983	-0.94	41	1 – 93	9
H049	West Sousa Creek	58.60	-118.67	984	-0.64	40	6 – 92	18
H050	East Sousa Creek	58.59	-118.49	836	-0.51	27	1 – 89	9
H051	Chinchaga River via HWY 58	58.60	-118.33	10,600	-0.23	34	1 – 91	17
H052	Unnamed Creek via HWY 58	58.61	-118.28	278	-0.34	43	6 – 95	9
H059	Hutch Creek	58.81	-117.42	124	-0.83	46	9 – 99	20
L06	Scotty Creek	61.42	-121.46	130	-2.33	41	1 – 94	35
L07	Poplar River	61.34	-121.80	1650	-2.65	33	12 - 73	8
L12	Birch Creek	61.33	-122.01	551	-2.40	31	9 – 71	8
M064	Jean Marie River	61.44	-121.24	1260	-2.51	33	7 – 99	25
M076	Sambaa Deh (Trout River)	61.14	-119.85	9060	-2.80	45	10 – 99	18
M079	Red Knife River	61.15	-119.34	1850	-2.39	63	11 – 87	9
M083	Axe Handle Creek	61.09	-118.72	529	-2.32	59	13 – 93	9
M087	Kakisa River	60.98	-117.24	15,800	-2.39	47	16 – 99	20
M100	Buffalo River	60.72	-114.91	18,000	-2.17	53	10 – 99	13
M105	Little Buffalo River	60.05	-112.77	3340	-1.55	36	18 – 99	11

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Catchment delineation and key catchment characteristics were determined using ArcGIS Pro (Table 1). Catchment delineations and size were determined by using DEM models or, when available, were based on delineations from the National Hydrometric Network Basin Polygons (Natural Resource Canada, 2022). The remaining characteristics were extracted using existing geospatial data. The catchments varied in terms of permafrost extent, with the southernmost being within the absent to sporadic permafrost zones, and the northernmost reaching the beginning of the discontinuous permafrost zone (Heginbottom et al., 1995). MAT, a driving factor of permafrost development, was accessed using the western North America dataset from ClimateNA v7.41 (Wang et al. 2016; Smith et al. 2022). This was used as a continuous proxy of permafrost extent, where the warmest MAT was assumed to have the least permafrost and the coldest the most. Furthermore, the base land cover data that was used to determine wetland cover was the Landsat origins 2019 land cover map from Hermosilla et al. (2018; 2022). This was modified, as described in Shewan (2024) to mitigate the impacts of disturbances such as wildfire on peatland classification issues.

2.2 Sample collection and field measurements

We collected unfiltered water samples for total mercury (THg) and total methylmercury (TMeHg) analysis (see below) in new 125 mL and 250 mL, respectively, pre-cleaned amber borosilicate glass bottles. The samples were collected using the "clean-hands, dirty-hands technique" (St. Louis et al., 1994). Samples were preserved using 0.2% and 0.4% trace-metal grade hydrochloric acid for THg and TMeHg samples, respectively. Filtered and acidified water samples were collected for Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) analysis, and combustion catalytic oxidation analysis of DOC /total dissolved nitrogen (TDN). These samples were filtered on site through 0.7 µm GF/F Whatman filters into 60 mL acid-washed amber borosilicate glass bottles and preserved with 600 µL of 3M hydrochloric acid. Filtered but not acidified samples were collected for UV-Vis absorbance analysis, also collected in 60 mL acid-washed amber borosilicate glass bottles. Both 60 mL amber bottles were kept cool during field transit and refrigerated upon return until they were analyzed. Lastly, we collected filtered, non-acidified samples for colorimetric ion analysis and alkalinity analysis in 60 mL Thermo Scientific Nalgene Narrow-Mouth LDPE bottles which were frozen on site until analysis.

Field measurements were taken at all sampling occasions of river temperature, pH, specific conductivity (SC), and turbidity. In 2021 and 2022, a calibrated Elite PCTS pH/Conductivity/TDS/Salinity Pocket Tester was used to collect field measurements (Thermo Scientific, USA), along with a calibrated LaMotte 2020i Turbidity Meter for turbidity measurements (LaMotte, USA). In 2023 and 2024, a calibrated YSI ProDSS was used to collect all field measurements (Xylem, USA). Field measurements were taken ~15 cm below the river water surface, with readings recorded once stable measurements were observed (~2-5 min).

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2.3 Sample analysis

Sample analyses were done at the University of Alberta in Edmonton, Canada, at the Biogeochemical Analytical Service Laboratory (BASL; certified and accredited with the Canadian Association for Laboratory Accreditation), the Catchment and Wetland Sciences Research Group Laboratory (CAWS), and the Natural Resources Analytical Laboratory (NRAL). Concise analysis methods are provided below, for detailed analysis procedures, see Section S1 in the Supplementary Materials.

Analysis of THg and TMeHg were conducted at BASL. THg samples were analyzed using the EPA Method 1631 using a Tekran 2600 Automated Total Mercury Analyzer (Tekran Instruments Corporation, USA). The detection limit for THg was 0.06 ng L^{-1}. TMeHg samples were analyzed using the EPA Method 1630. Samples were distilled at 127ºC using a Tekran 2750 Methyl Mercury Distillation System for up to 4 hours (Tekran Instruments Corporation, USA). The samples were then analyzed using a Tekran 2700 Methyl Mercury Analyzer coupled with an Agilent 7900 ICP-Mass Spectrometer (ICP-MS) (Tekran Instruments Corporation, USA; Agilent Technologies, USA). The detection limit for TMeHg was 0.01 ng L^{-1}. UV-Vis absorbance at 254 nm (A_{254}) was measured using a Shimadzu UV-1280 Spectrophotometer using a 1 cm quartz cuvette at room temperature, within one week of collection (Shimadzu Corporation, Japan) at the CAWS Lab. Ultrapure water blanks were run every 10 samples, and the blank measurements were subtracted from the absorbance measurements. Specific UV absorbance at 254 nm ($SUVA_{254}$) is an indicator of DOC aromaticity and was calculated by dividing A_{254} by the DOC concentrations, multiplied by 100 (Weishaar et al., 2003).

DOC and TDN were measured through combustion catalytic oxidation at NRAL using a Shimadzu TOC-L CPH Model Total Organic Carbon Analyzer with an ASI-L and TNM-L (Shimadzu Corporation, Japan). ICP-OES analysis, colorimetric ion analysis, and alkalinity analysis were also done at NRAL. The ICP-OES analysis was done using a Thermo iCAP6300 Duo (Thermo Fisher Scientific, USA), and yielded concentrations of Ca, Fe, Mg, S, and P. Colorimetric ion analysis was done using a Thermo Gallery Plus Beermaster Autoanalyzer (Thermo Fisher Scientific, USA), and yielded concentrations of SO_4-S, NO_3^--N + NO_2^--N, SRP (PO_4-P), and NH_4-N. Alkalinity as carbonate was measured using a Schott Instruments Titronic Universal automatic titrator. A small number of ion and nutrient analyses completed produced values below either the level of quantification (LOQ) or level of detection (LOD). If concentrations were provided by the lab despite being below LOQ or LOD, these concentrations were used. If there was no concentration provided, we used the value equal to the LOQ. The percentage of < LOQ and LOD values, as well as the percentage of values substituted with the LOD can be found in the Supplementary Materials (Table S1).

2.4 Flow percentile

Hydrological conditions at each sampling site and occasion were estimated using flow percentile as our measure of relative streamflow. Ten of the 27 monitored streams had long-term hydrological records maintained by Water Survey of Canada

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(WSC) (WSC, 2025) (Table S2). These gauged streams all had available daily data for April to October for the period between 1995 and 2024. This daily streamflow data was used to calculate flow percentile:

$$Flow\ Percentile = 100 - \left(\left(\frac{r}{n+1}\right) x\ 100\right)$$

r = the rank of the discharge data within the time series for a given station

n = the number of discharge records used

This formula shows flow exceedance subtracted from 100 to convert the value to flow percentile. Therefore, a higher flow percentile value indicates that the stream was at the highest potential flow measured since 1995 (i.e., there is a low probability that this flow could be exceeded). For detailed flow percentile methodology, see Section S2 in the Supplementary Materials. For ungauged streams, we used the average of between one and three nearby gauged basins, considering both distance to gauged stations and similarities in catchment size (Table S3).

2.5 Statistical analysis

We checked the water chemistry data for outliers to be removed prior to statistical analysis. Water chemistry data were largely non-normally distributed after assessing histograms and performing Shapiro-Wilk statistical tests for normality. Four datapoints of THg and TMeHg had concentrations >100% greater than site averages, but these were collected during periods of high flow and were thus considered valid. No DOC or A_{254} data were >100% higher than site averages, and all were kept. Nutrient data (TDP, SRP, TDN, $NO_2^- + NO_3^-$, NH_4^+-N) were more variable and given the localized nature of these solutes, none were removed. This was determined by considering flow conditions, turbidity, water temperature, and other physical water characteristics that can be used to identify outliers. Covariance among water quality parameters was assessed by looking at pairwise Pearson's correlations and by conducting a principal component analysis (PCA). The data for the PCA was standardized by standard deviation due to varying scales of variables but was not transformed. The number of components were selected using the Kaiser Criterion for eigenvalues (>1) cautiously. PC1 - PC5 had eigenvalues that could justify their retention, with PC1 and PC2 having high eigenvalues (PC1 = 5.01, PC2 = 4.58). However, there was a marked decline in eigenvalues after PC2 (PC3 = 1.97, PC4 = 1.15, PC5 = 1.08). Despite PC3 - PC5 meeting the criterion, this decline indicated that the dominant multivariate structure was captured by the first two components. Interpretation was therefore accordingly focused on the first two PCs as they captured the dominant variance structure and provided the clearest ecological gradients, and the additional components seemed to add unnecessary complexity if all five components were retained (Jackson, 1993).

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To evaluate how stream water chemistry was influenced by interactions between catchment characteristics and hydrological conditions, we employed a series of Linear Mixed Effects Models (LMMs). We included Stream ID to account for the non-independence of observations in repeated sampling of individual streams. Models were run for the following eleven variables: TMeHg, DOC, A_{254}, $SUVA_{254}$, THg, Turbidity, TDP, SRP, TDN, $NO_2^- + NO_3^-$, NH_4^+, and SC. For each solute, we compared twelve candidate models which included combinations and interactions among hydrological conditions (flow percentile) and catchment characteristics: MAT (as a proxy of permafrost prevalence), size, peatland extent, and the presence or absence of recent wildfires in the catchment. For a list of the twelve candidate models generated for each solute, see Section S3 in the Supplementary Materials.

For each solute we identified the most parsimonious model based on the lowest Akaike Information Criterion (AIC) followed by choosing models that had the lowest p-value scores for each variable within a model (Buscemi and Plaia, 2020). AICs were the primary metric; however Root Mean Squared Error (RMSE) and p-values were cautiously used to support the best selection of a models as models with a high number of predictors can arbitrarily reduce AIC (Sutherland et al., 2023). The LMMs used the R package *lme4* (Bates et al., 2015), and the associated p-values to test whether predictors significantly impacted solute concentrations were calculated using the *lmerTest* R package (Kuznetsova et al., 2017) using Satterthwaite's Approximation. Given the fact that AICs were needed to compare the models for best fitness, LMMs by Maximum Likelihood were completed compared to a Restricted Maximum Likelihood approach. All statistical analysis was completed in R Version 4.4.2 (November 2024).

3. Results

3.1 Spatial and temporal variability in river chemistry

Stream sampling at all 27 sites included samples from both high and low streamflow, with most sites sampled at stream flow between <15th and >95th percentiles (Table 1). Median TMeHg concentrations among sites ranged between 0.05 and 0.25 ng L^{-1}, with less variability for colder, northern sites relative to warmer, southern sites (Figure 2a). Similar patterns were found for DOC and A_{254}, where median DOC concentrations ranged between 8 and 35 mg L^{-1} (Figure 2b-c). Median SUVA across sites, indicating DOC aromaticity, varied only between 2.5 and 4.0 L mg C^{-1} m^{-1}, suggesting a dominance of terrestrially derived DOC in all streams (Figure 2d). Turbidity and THg generally had greater variability in rivers with larger catchments (Figure 2e-f).

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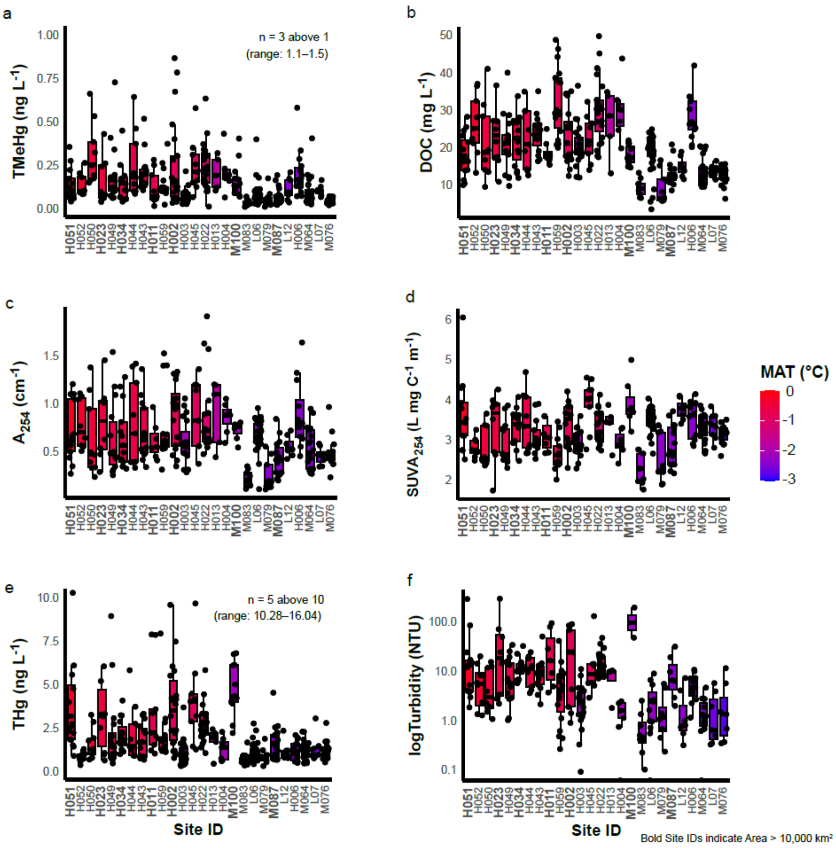

Figure 2. Boxplots of water chemistry parameters across 27 sites by Site ID, and coloured/ordered by MAT. Panels show (a) TMeHg, (b) DOC, (c) A_{254}, (d) $SUVA_{254}$, (e) THg, and (f) turbidity. Bolded site IDs indicate catchment areas greater than 10,000 km^2. The number of samples with high concentrations not shown in the figure are indicated on top right.

Dissolved inorganic nitrogen (NH_4^+, NO_3^-, NO_2^-) and inorganic phosphorous (SRP) represented small proportions of TDN (median 4% for samples where measurements were >LOD) and TDP (median of 26%), respectively (Figure 3). Relative variability in TDP and TDN was similar to that of DOC with site median TDP and TDN concentrations ranging from 0.01 to 0.07 mg P L^{-1} and 0.5 to 2.0 mg N L^{-1}, respectively (Figure 3a and c). Inorganic nutrients (NH_4^+, NO_3^- + NO_2^-, SRP) had greater relative variability, with ~10% of samples having concentrations >10 times higher than the median concentration (Figure 2b, d-e). Site median SC varied between 250 and 850 µS cm^{-1} (Figure 3f).

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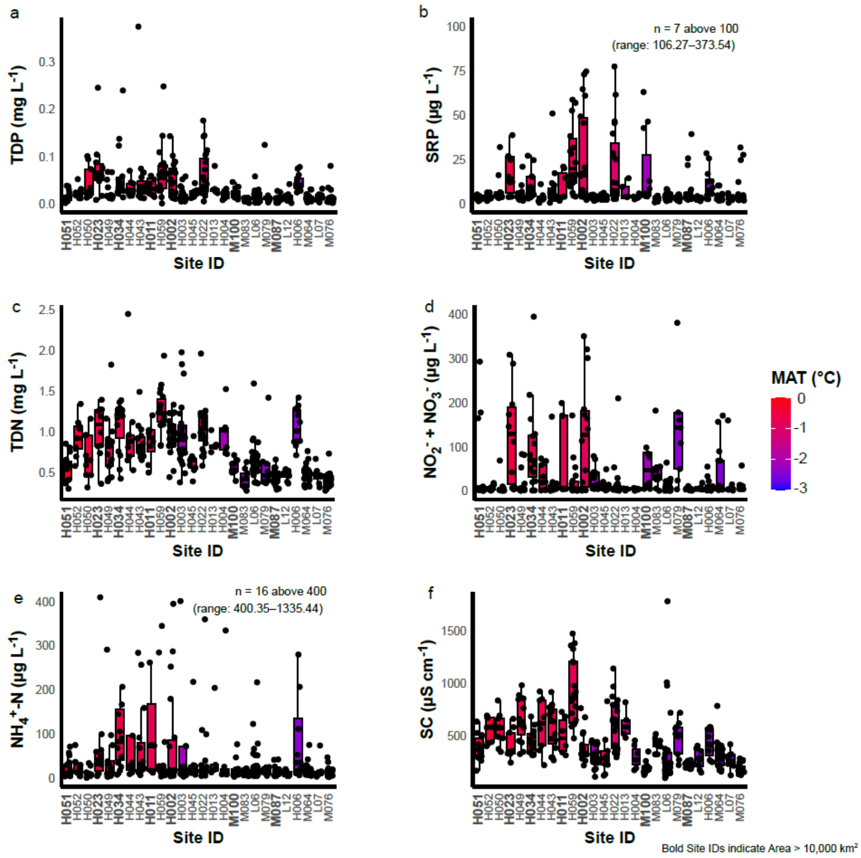

Figure 3. Boxplots of water chemistry parameters across 27 sites by Site ID, and coloured/ordered by MAT. Panels show (a) TDP, (b) SRP, (c) TDN, (d) NO_2^--N + NO_3^--N, (e) NH_4^+-N, and (f) SC. Bolded site IDs indicate catchment areas greater than 10,000 km². The number of samples with high concentrations not shown in the figure are indicated on top right.

Two principal components in a PCA explained 56.5% of the total variance (Figure 4). Principal component 1 (PC1, 29.5%) is representative of flow conditions, with higher flows promoting the mobilization of solutes, such as THg, sediment-associated parameters, and DOC aromaticity (i.e., $SUVA_{254}$), while dissolved inorganic ions become diluted, reflecting the typical riverine pattern of increased suspended material and terrestrial DOC transport and dilution of solutes during high discharge. Principal component 2 (PC2, 27%) is representative of temperature influences, showing that warmer catchments exhibit greater mobilization of both organic and inorganic solutes compared to colder, northern catchments, where solute responses remain comparatively muted across flow conditions, particularly for peat-sourced solutes such as TMeHg and DOC. Section S4 in the Supplementary Materials includes a correlation matrix (Figure S1), as well as a PCA that includes turbidity (Figure S2), which showed that turbidity was associated with higher THg, Fe, $SUVA_{254}$ and higher streamflow. Turbidity was excluded in Figure 4 as it was missing for 135/399 samples.

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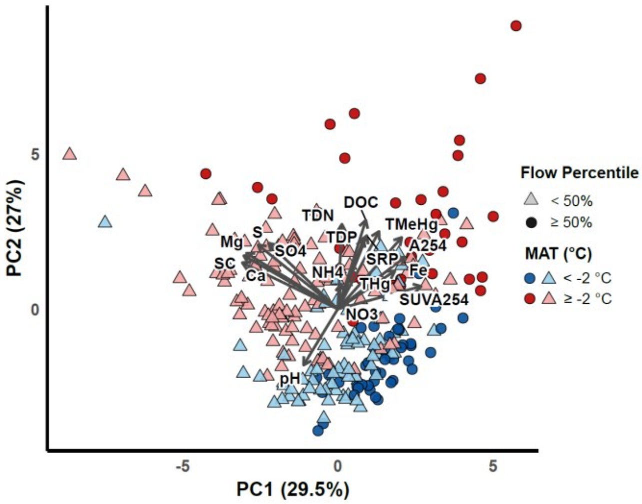

Figure 4. A PCA of water chemistry. Points represent individual samples, and arrows indicate the loadings of water chemistry variables on the first two principal components. Shapes represent high (circle) and low (triangle) flow conditions, with flow percentiles greater than 50% being high and lower than 50% being low flow. Colours represent the catchment MAT, where blue indicates a temperature less than -2ºC, and red indicates warmer, permafrost absent regions with MATs greater than or equal to -2ºC. Note: NO_2 contributed < 5% of oxidized N and is therefore reported as NO_3 for clarity.

Several water quality parameters were closely associated, suggesting potential co-mobilization within watersheds, including associations among TMeHg, THg, DOC, A_{254}, and turbidity (Figure 5). We split the data into high (>50th percentile) and low (<50th percentile) flow periods and performed simple log-log linear regressions of the parameters (e.g., DOC and TMeHg) stratified under each flow condition (high/low). Relationships, which were visually comparable during high and low flow periods, were likely due to consistent co-mobilization through similar biogeochemical processes regardless of flow condition. The relationships of TMeHg with DOC and A_{254} were visually similar at high and low flow conditions, albeit with stronger correlations during high flow periods. In contrast, the relationships of THg with DOC and A_{254} were weaker and showed that concentrations of THg were relatively higher during high flow periods. Both TMeHg and THg increased with turbidity during both low and high flow periods, but the relationships were much stronger for THg.

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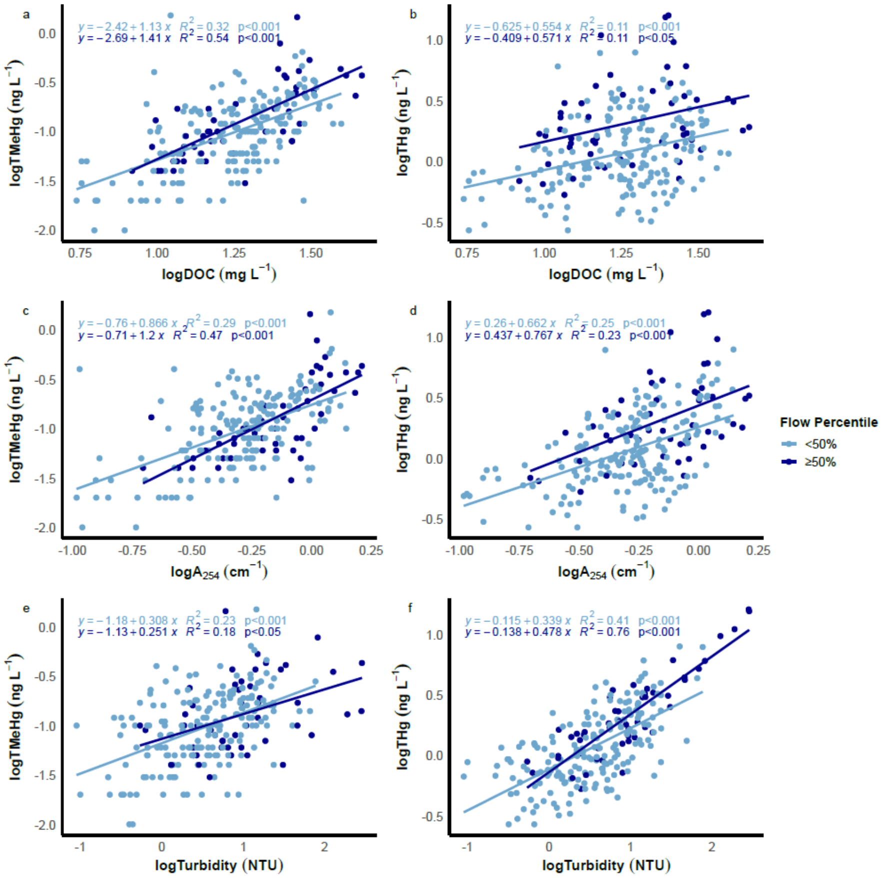

Figure 5. Log-form linear regressions of a) DOC and TMeHg, b) DOC and THg, c) A_{254} and TMeHg, d) A_{254} and THg, e) turbidity and TMeHg, and f) turbidity and THg. The colours represent flow conditions, with the lighter blue indicating lower flow conditions, and the darker blue indicating higher flow conditions. The linear equations, R^2, and p-values are indicated for each panel's regressions at high and low flow.

3.4 Interacting effects of catchment characteristics and hydrological conditions

The most parsimonious model for each water quality parameter was chosen among twelve candidate models (Table 2). Flow percentile had a significant ($p<0.05$) influence on all water quality parameters except NH_4^+ and NO_2^-+NO_3^-. Recent wildfires had no significant influence on any water quality parameter ($p>0.05$).

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Table 2. Most parsimonious linear mixed effects models for each water quality parameter, including their equations and associated p-values for each predictor included in the equation. Each parameter had twelve models ranked by AIC and significance (see Section S3 in Supplementary Materials). p-values < 0.001 = ***, p-values < 0.01 = **, p-values < 0.05 = *. Int = intercept. FP = flow percentile. MAT = mean annual temperature. Area = catchment area.

Parameter	Equation
TMeHg	0.19 × Int*** + 0.08 × FP*** + 0.07 × MAT** + 0.05 × FP:MAT***
DOC	20.7 × Int*** + 3.54 × FP*** + 3.93 × MAT*** + 1.50 × FP:MAT***
A_{254}	0.69 × Int*** + 0.19 × FP*** + 0.14 × MAT*** + 0.10 × FP:MAT***
$SUVA_{254}$	3.21 × Int*** + 0.31 × FP*** + -0.18 × Peat** + 0.10 × FP:MAT***
THg	2.23 × Int*** + 0.87 × FP*** + 0.67 × MAT*** + 0.56 × Area** + 0.57 × FP:MAT*** + 0.28 × FP:Area***
Turbidity	19.8 × Int*** + 14.5 × FP*** + 9.88 × MAT*** + 15.6 × Area*** + 8.95 × FP:MAT** + 15.4 × FP:Area***
TDP	0.03 × Int*** + 0.007 × FP*** + 0.01 × MAT*** + 0.006 × FP:MAT** + 0.006 × FP:Area**
TDN	0.79 × Int*** + 0.03 × FP* + 0.14 × MAT** + 0.03 × FP:MAT*
SRP	14.0 × Int*** + 5.76 × FP*** + 4.47 × FP:MAT**
NO_3^--N + NO_2^--N	47.0 × Int***
NH_4^+-N	65.5 × Int***
SC	435 × Int*** + -118 × FP*** + 73.4 × MAT* + -28.7 × FP:MAT** + 27.3 × FP:Area**

Concentrations of MeHg were influenced by both flow percentile, catchment MAT, and their interaction, while catchment area and peatland extent were non-significant. Visualizing the model for TMeHg showed that warmer catchments had a flushing response to increasing flow, while concentrations in colder catchments were chemostatic with no response to flow (Figure 6a). Similar models and flushing responses of warmer catchments were found for DOC and A_{254} (Figure 6b-c). Aromaticity ($SUVA_{254}$) had a partially different pattern, where aromaticity was higher in catchments with lower peatland extent but still increased with flow, especially for catchments in warmer climates (Figure 6d). Turbidity and THg were both also influenced by flow percentile, catchment MAT, and their interaction, but further had significant influences from catchment area and the interaction between catchment area and flow (Figure 6e-f).

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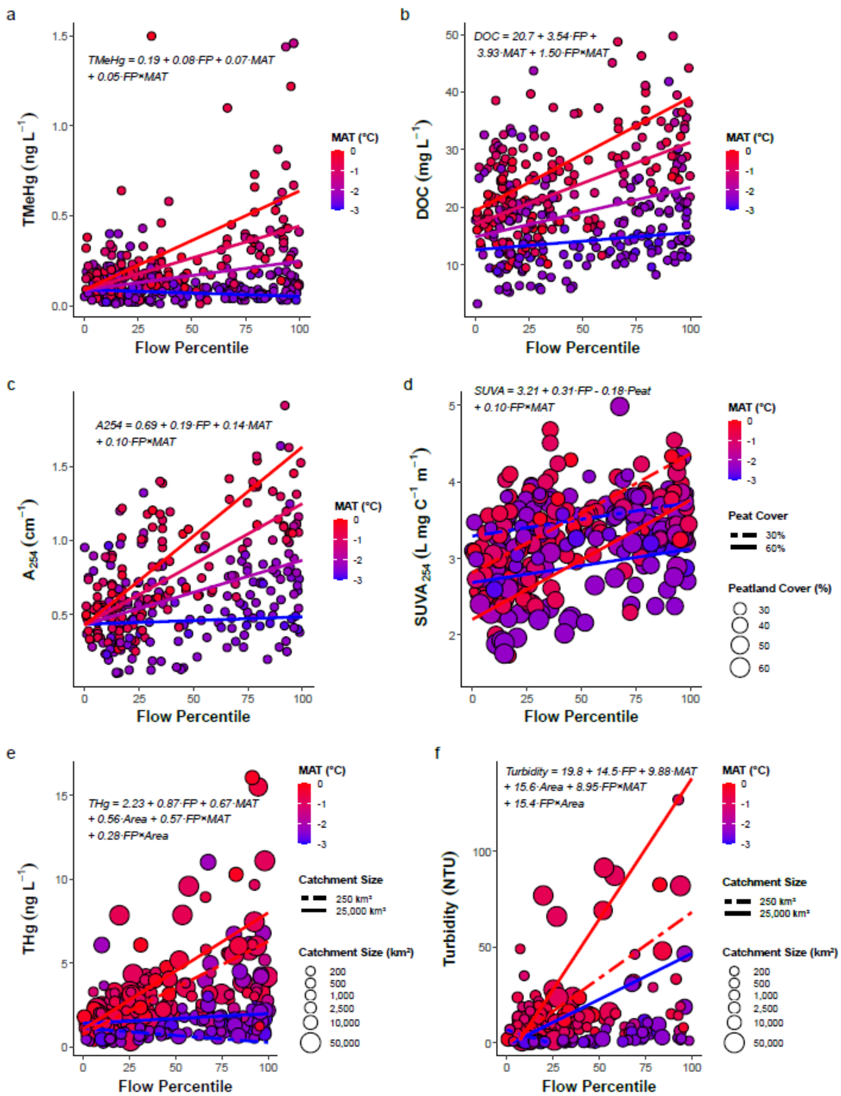

Figure 6. Visualizations of the LMMs conditional effects for a) TMeHg, b) DOC, c) A_{254}, d) $SUVA_{254}$, e) THg, and f) turbidity were plotted in addition to the observed collected data. The LMM equations are included in each panel and predict data. For TMeHg, DOC, and A_{254} this was done at four intervals of MAT (0ºC, -1ºC, -2ºC, and -3ºC). For $SUVA_{254}$, THg, and turbidity, two intervals of MAT (0ºC and -3ºC) were used to represent the extremes of MAT. MAT is represented by colour in the figure with the associated legend. $SUVA_{254}$ had models run at 30% or 60% peatland catchment cover, and THg and turbidity models ran at 250 km^2 and 25000 km^2. This is illustrated by a line pattern.

Models of TDN, TDP, and SRP all indicated greater flushing responses in warmer catchments, although this response was less apparent for TDN (Figure 7a-c). In addition, TDP was further influenced by catchment size, with stronger flushing

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responses in larger catchments. Neither flow nor any catchment characteristics influenced NH_4^+ and $NO_2^-+NO_3^-$ (7d-e). Lastly, SC had a dilution response to higher stream flow, where dilution was more pronounced for smaller catchments. Catchments in warmer climates also had higher SC, especially during low flow conditions (Figure 7f). Lastly, SC was higher in catchments with warmer climates, and SC had a dilution response to increasing streamflow which was more pronounced for smaller catchments and catchments in warmer climates (Figure 7f).

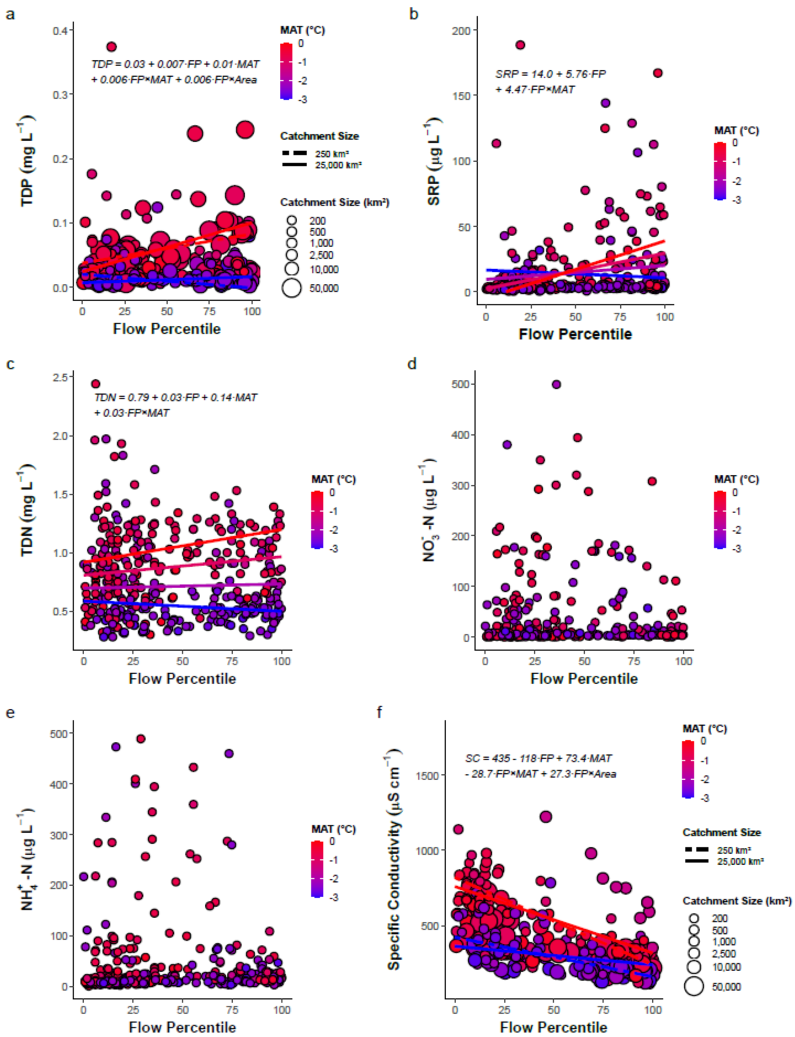

Figure 7. Visualizations of the LMMs conditional effects for a) TDP, b) SRP, c) TDN, d) $NO_2^- + NO_3^-$, e) NH_4^+-N, and f) SC were plotted in addition to the observed collected data. The LMM equations are included in each panel and predict data. $NO_2^- + NO_3^-$ and NH_4^+-N do not have models plotted as no model was statistically significant. For SRP and TDN this was done at four intervals of MAT (0°C, -1°C, -2°C, and -3°C). For SC and TDP, two intervals of MAT (0°C and -3°C) were used to represent the extremes of MAT. MAT is represented by colour in the figure with the associated legends. SC and TDP also had models that ran at 250 km^2 and 25000 km^2. This is illustrated by a line pattern.

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4. Discussion

We studied 27 peatland-dominated catchments across a permafrost gradient over a five-year period which captured extreme wet and dry periods. Our results showed that permafrost conditions strongly influenced C-Q relationships of several peatland-derived solutes, particularly DOC and MeHg. Warmer catchment south of the permafrost boundary had strong flushing during wet periods while northern catchments showed chemostatic behaviour. SRP, TDN, and TDP were influenced by permafrost conditions in peatland catchments, whereas NH_4^+ and NO_3^- showed little relationship with permafrost. TDP and THg were associated with in-stream erosional processes, suggesting that sediment resuspension and bank erosion rather than peatland permafrost dynamics play a key role in their transport. Below we expand on these findings, with discussion around putative processes and implications for water resource management.

4.1 MeHg and DOC flush during floods in non-permafrost peatland catchments

Higher concentrations of DOC and MeHg observed in southern catchments were consistent with the greater extent of permafrost-free peatlands, which are known hotspots of DOC and MeHg production (Olefeldt and Roulet, 2014; Thompson et al., 2025). The absence of permafrost enhances hydrological connectivity and facilitates the transport of solute-rich waters to streams (Quinton, 2009), while ongoing thaw further increases connectivity through the transition of peat plateaus to wetlands (Robinson and Moore, 2000; Quinton et al., 2011). Therefore, the effective contributing area of these catchments remains high as there are no specific barriers to flow from permafrost, meaning that water can more easily be transmitted through peatlands and to the stream network.

A flushing relationship, where increases in discharge caused an increase in MeHg and DOC concentration and aromaticity (as well as TDN), occurred in catchments south of the permafrost boundary. Contrarily, many studies have shown that peatland-dominated catchments (> 25% peat cover) exhibit a chemostatic or dilution response following higher flow events (Eckhardt and Moore, 1990; Hinton et al., 1998; Laudon et al., 2011; Gomez-Gener et al., 2021; Thompson et al., 2023a; Orlova et al., 2024). We hypothesize that the drier climate of subhumid western Canada is more likely than in other peatland regions to lead to runoff cessation during droughts, such that peatlands become disconnected from downstream creeks and rivers. Evidence for this process has been observed previously where droughts led to decreases in DOC concentration and $SUVA_{254}$, as well as concurrent increases in SC, suggesting reduced run-off generation from peatlands and rather that during drought, deeper groundwater becomes the primary source of DOC (Connon et al., 2015; McDonough et al., 2022; Tiwari et al., 2022; Orlova, 2024). Furthermore, the hydrology in the Taiga Plains is typically characterized by a nival regime, where the highest flows are present during the spring freshet when infiltration is limited by frozen ground. Summer flow is governed by rainfall events, and streamflow responses can be significantly dampened by the large storage capacity of wetlands under dry conditions. Antecedent basin moisture conditions can therefore lead to considerable inter-annual variability in runoff (Quinton et al., 2009). Consequently, given the high storage capacity of peatlands that also likely

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became hydrological disconnected it is plausible that during drought concentrations decrease markedly. Therefore, during high flow periods (i.e., more consistent precipitation during the summer), the relative increase in peatland run-off generation and peat-sourced sub-surface in the permafrost absent regions resulted in a flushing C-Q relationship of DOC, as well as MeHg. Thus, peatlands in the non-permafrost region appear highly sensitive to extreme droughts and floods.

4.2 Peatland permafrost causes chemostasis of MeHg and DOC in northern streams

Permafrost extent likely exerted a strong control on the C-Q relationships of MeHg and DOC, likely by influencing hydrological flow paths and solute mobilization. Compared to southern rivers, C-Q relationships of MeHg and DOC in the northern permafrost catchments exhibited a chemostatic response, with relatively equal concentrations both during wet and dry conditions. We postulate that the absence of a flushing C-Q relationship in the permafrost region of our study is due to the role of permafrost a higher proportion of peatland cover remains hydrologically disconnected from the stream network regardless of hydrological conditions (Quinton, 2009). Isolated thermokarst wetlands are often encircled by permafrost underlain peat plateaus that prevents surface and subsurface runoff, whereby evapotranspiration is often the only process for water loss. As a result, these catchments function as though they have a substantially smaller effective contributing area than would be the case in a permafrost free landscape, where the wetlands could transmit water downstream. Furthermore, increased permafrost and frozen soils have been found to suppress methylation (Gordon et al., 2016; Thompson et al., 2025), which inherently leads to lower concentrations within colder catchments with more extensive permafrost.

While peat plateaus can produce DOC under unsaturated conditions, they are unlikely to be significant sources of MeHg due to conditions that suppress the activity of microbial methylators, including cooler temperatures, a lack of terminal electron acceptors, and predominantly aerobic conditions (Olefeldt and Roulet, 2014; Thompson et al., 2025). These peat plateaus physically disconnect and fragment the landscape, limiting transportation pathways for solutes through the catchment (Quinton et al., 2009). Therefore, we propose that even if there is the transportation potential in terms of water available by volume to hydrologically move solutes, the permafrost peat plateaus act as physical barriers to block the movement of these solutes from producing regions on the landscape to the streams for downstream export, regardless of the hydrological condition of the year. The concurrent lack of mobilization of both DOC and MeHg during high flows suggests that transport limitations, rather than production constraints, are the primary control on concentrations in the permafrost region. If DOC had been flushing while MeHg remained chemostatic, then peat plateau production of DOC would be a more plausible explanation. In other words, large portions of peatlands in these landscapes remain hydrologically isolated and “locked” throughout the year, with runoff directed into closed bog systems that do not connect to streams.

Northern peatlands that are hydrologically connected in the permafrost region may maintain that connectivity more reliably than their counterparts further south. Narrow channel (thermokarst) fens in permafrost-rich regions often concentrate flow into confined peatland corridors, increasing the likelihood of sustained connectivity even during dry periods (Quinton, 2009;

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Olefeldt & Roulet, 2012; Olefeldt & Roulet, 2014). In addition, lower evapotranspiration rates and shorter growing seasons in the colder climate likely reduce the potential for severe drought-induced disconnection. The net effect is that hydrological connectivity in the permafrost region may change very little between wet and dry years, with peatlands falling into two relatively stable categories: those that are almost always connected and those that are almost always disconnected.

This stability contrasts with the non-permafrost region, where peatlands are more hydrologically dynamic, readily connecting to streams during high flows and disconnecting during drought (Niu et al., 2011; Quinton et al., 2011; Connon et al., 2014; Walvoord & Kurylyk, 2016). Ergo in the discontinuous permafrost zone the presence of peat plateaus possibly continue to release water from deepening of the active layer throughout the summer, and water is conveyed in spatially constricted channel fens to the stream outflow. In short, non-permafrost peatlands are likely to be even more transport limited during droughts compared to the northern permafrost region in our study, as peat plateau supply meltwater through the season and channel fens concentrate runoff through peatlands. Additionally, the non-permafrost peatland regions in boreal western Canada are more likely to be more transport limited than other, wetter counterparts globally.

4.3 Inorganic nutrient concentrations reflect localized processing

We found limited evidence for an effect of peatland permafrost conditions on the concentrations of inorganic nutrients (NH_4^+, $NO_2^- + NO_3^-$, SRP) in the study region, where only SRP showed slight flushing in catchments where permafrost was absent. The effects of permafrost thaw, wildfire disturbance, and hydrological variability on inorganic nitrogen and phosphorus are often inconsistent due to the complex interplay among biogeochemical processes, landscape heterogeneity, and temporal variability (Vorobyev et al., 2017; Krickov et al., 2018; Moore et al., 2019). Determining the specific reason as to why there was no wildfire response within the region proves challenging. There may have been significant transformations and changes of solutes on the landscape, but without any surface water exports to connect those catchment responses to the streams of interest, detecting a wildfire response was not possible with our data (Ackley et al., 2021). Continued monitoring at these sites is imperative so that differences can be examined should hydrologic connectivity increase in the landscape and facilitate change sin solute transport through the watershed.

The distribution of inorganic nutrient concentrations across the study sites was characterized by a strong baseline, with most samples clustering at low concentrations but punctuated by occasional measurements that were substantially higher. This pattern suggests that nutrient concentrations in these rivers can change rapidly over relatively small temporal and spatial scales, reflecting localized production, transformation, and removal processes such as uptake, mineralization, and sediment–water exchange (Blaen et al., 2014; O'Donnell et al., 2021). Despite this high variability, SRP showed a tendency toward higher concentrations during high-flow events in non-permafrost catchments, indicating that increased runoff can mobilize phosphorus sources likely from riparian zones or surface soils that are not as strongly activated in the permafrost region.

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Consequently, nutrient export patterns are frequently non-linear, temporally dynamic, and site-specific, leading to variable and sometimes contradictory outcomes across studies and regions (Frey et al., 2007; Burd et al., 2018; Shogren et al., 2019).

4.4 THg, TDP, and SC were controlled by catchment size and geology rather than peatland permafrost conditions

Catchment size was a significant predictor for THg, TDP, and turbidity, with larger catchments flushing these parameters much more compared to smaller catchments. This is likely since THg and TDP are commonly sediment bound in addition to being bound to DOC, and therefore more turbid environments at higher flows create ideal conditions for the riverine movement of these solutes (Pettersson et al., 1988; Staniszewska et al., 2023). Smaller catchments generally had lower concentrations, and a less extreme flushing response during high flows. Larger rivers have more energy, leading to higher transport potential, compared to smaller creeks which can lead to the upturning of sediments to create more turbid conditions (Pilgrim et al., 1982; Evans et al., 2006; Ramchunder et al., 2011). Additionally, there is a greater capacity for in-channel sediment storage along with enhanced potential for bank erosion (Shrestha and Wang, 2018). Both of which can contribute to increased sediment mobilization and erosion of mineral substrates along riverbanks where stores of THg and TDP can be found.

MAT had a significant chemodynamic influence on THg and TDP. However, it is possible that this is a representation of surficial geological differences between the northern and southern catchments that are being showcased rather than an influence of permafrost conditions. The southern catchments around the Hay River basin have more fine-grained lacustrine surficial geology, while the northern catchments are dominated by moraines (till blankets) (Government of Canada, 2025). Lacustrine sediments are much easier to erode when a river cuts through them, and given that both surficial geology and MAT follow similar trends, THg and TDP are potentially controlled by the erodibility of the creeks and rivers that are being sampled, rather than peat-driven and permafrost related processes, as was the case for TMeHg and DOC, where catchment size was a non-significant predictor (p-value > 0.05) (Pilgrim et al., 1982; Evans et al., 2006; Ramchunder et al., 2011; Shrestha and Wang, 2018). For MeHg, production is enhanced by anoxic conditions typically found within peatlands. Increases in MeHg in this region were found to be associated with parameters (DOC, A_{254}, higher MAT) that are indicators of peatland, rather than from particle bound sediments. Instead, the concurrent behaviour of MeHg and DOC across sites is more consistent with both being mobilized from peatland sources rather than from in-channel transformation of sediment inputs associated with THg and TDP.

Catchment size was only relevant within the context and interaction of hydrological conditions for SC, where increasing flows led to a dilution of SC, likely attributed to the relative contribution of groundwater inputs being lessened as surface water inputs increased (Pettersson et al., 1988). Groundwater associated solutes were higher in warmer, southern catchments compared to colder, northern catchments. Although permafrost degradation has been found to enhance groundwater pathways (Frey and McClelland, 2009), geology may again be a more dominant driver than permafrost extent. The Hay

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River basin, which is largely in the southern extent of this study, has discharge zones with higher groundwater contributions (Tokarsky, 1972; Borneuf and Pretula, 1980; Government of Canada, 2025). Therefore, hydrogeological differences are the potential driver of SC decreasing with MAT as these discharge zones are not as extensive in the northern Mackenzie basin.

Still, at high flows, the contribution of groundwater is often diluted by surface water inputs such as snowmelt or precipitation runoff, causing a reduction in ion concentrations, regardless of permafrost extent. During low-flow periods, groundwater becomes the primary source of water, and therefore the relative contribution of groundwater during drought periods increases, and so SC was increased at low flows. Increased groundwater influence has been associated with lower DOC concentrations as many minerals can adsorb DOC (Kaiser and Zech, 1998). Additionally, the increased relative importance of groundwater represented by higher SC during drought conditions reinforces the claim that in the permafrost absent regions, that peatland connectivity to streams declined during low flows. Notwithstanding, it is likely that reduced surface water inputs simply increased the importance and significance of groundwater inputs as during regular hydrological years, these elements and ions are usually diluted (Laudon et al. 2011; Goodbrand et al. 2019).

5. Conclusion

In summary, this study highlights that permafrost conditions control the C-Q relationship of solutes and parameters that are associated with peatland connectivity and solute production, namely MeHg and DOC. Ongoing climate change is expected to intensify the frequency and severity of both extreme floods and droughts, accelerate permafrost thaw, increase solute mobilization, and increase wildfire occurrence across the circumpolar north (Nilsson et al., 2015; Dastoor et al., 2022; Wright et al., 2022; Burton, 2023). As these landscape disturbances continue to increase with time, we predict that the degradation of permafrost in northern peatlands may enhance the production and the mobilization of MeHg and DOC in currently low-yielding systems, as well as increase the sensitivity of these systems to floods and droughts, akin to what we have observed in the southern catchments of this study.

This interpretation of future trajectories relies on a space-for-time substitution of these catchments (Wig et al., 2025). By using the spatial extent of permafrost conditions as an analogue to permafrost thaw, we predict that as climate change continues and hydrological variability increases alongside thawing permafrost (coupled with enhanced DOC and MeHg production with warmth), northern catchments will lose the stabilizing action of permafrost and flushing of these solutes may be observed. We assume that as permafrost thaws, northern permafrost-rich catchments will increasingly resemble southern, non-permafrost catchments. If this substitution holds, continued permafrost loss can be expected to increase the delivery of DOC and MeHg to downstream aquatic ecosystems as these northern ecosystems warm. Such changes have the potential to enhance eutrophication, accelerate MeHg bioaccumulation, alter water colour with increased DOC, and increase aquatic greenhouse gas emissions. These findings highlight the importance of long-term monitoring of DOC, MeHg, and nutrient fluxes in northern rivers, particularly within regions experiencing rapid permafrost degradation, to detect and manage emerging risks to water quality and ecosystem health, and to ensure traditional land use can occur safely.

Data availability

In line with the journal's data policy recommendations, the complete dataset has been included as part of this submission to demonstrate our commitment to open science; we intend to host the final version on an open-source repository, which currently has data up to 2022 but will be updated to include 2023-2024 data as well in the coming weeks. The link can be found here: https://doi.org/10.25976/ndf7-nu19

Supplement link

The link to the supplement will be included by Copernicus, if applicable.

Author contributions

Fares Mandour: Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, visualization, writing – original draft, writing – review & editing. **Jazmin Greyeyes-Howell:** Formal analysis, investigation, methodology, writing – review & editing. **Renae Shewan:** Data curation, formal analysis, investigation, methodology, writing – review & editing. **Lauren Thompson:** Data curation, formal analysis, funding acquisition, investigation, methodology, writing – review & editing. **Irene Graham:** Investigation, methodology. **Mike Low:** Investigation, methodology. **Matthew Munson:** Investigation, methodology. **Ryan Connon:** Conceptualization, funding acquisition, methodology, project administration, supervision, validation, writing – review & editing. **Christopher Cunada:** Conceptualization, funding acquisition, methodology, validation, writing – review & editing. **Craig Emmerton:** Conceptualization, funding acquisition, methodology, validation, writing – review & editing. **David Olefeldt:** Conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, resources, supervision, validation, writing – review & editing.

Competing interests

The authors declare that they have no competing interests.

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During the preparation of this work the author(s) used Gemini in order to check the flow and logic of paragraphs within the introduction and discussion. No content in the work was explicitly written by AI. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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Review statement

The review statement will be added by Copernicus Publications listing the handling editor as well as all contributing referees according to their status anonymous or identified.

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References

Ackley, C., Tank, S. E., Haynes, K. M., Rezanezhad, F., McCarter, C., and Quinton, W. L.: Coupled hydrological and geochemical impacts of wildfire in peatland-dominated regions of discontinuous permafrost, Science of The Total Environment, 782, 146841, https://doi.org/10.1016/j.scitotenv.2021.146841, 2021.

Aggarwal, P., Gaur, S., and Gauba, P.: Neurotoxic and genotoxic effects of methylmercury, Environ. Dev. Sustain., 16, 71-78, https://doi.org/10.1007/s10668-013-9475-8, 2014.

Ayala-Borda, P., Lovejoy, C., Power, M., and Rautio, M.: Evidence of eutrophication in Arctic lakes, Arctic Sci., 7, 859-871, https://doi.org/10.1139/as-2020-0033, 2021.

Bates, D., Mächler, M., Bolker, B., and Walker, S.: Fitting linear mixed-effects models using lme4, J. Stat. Softw., 67, 1–48, https://doi.org/10.18637/jss.v067.i01, 2015.

Bieroza, M. Z., Heathwaite, A. L., and Bechmann, M.: The concentration–discharge slope as a tool for water quality management, Sci. Total Environ., 630, 738–749, https://doi.org/10.1016/j.scitotenv.2018.02.256, 2018.

Blaen, P. J., Milner, A. M., Hannah, D. M., Brittain, J. E., and Brown, L. E.: Impact of changing hydrology on nutrient uptake in high Arctic rivers, River Res. Appl., 30, 1073–1083, https://doi.org/10.1002/rra.2706, 2014.

Borneuf, D. M. and Pretula, B.: Hydrogeology of the Zama-Bistcho Lakes area, Alberta, Alberta Geological Survey, ARC/AGS Earth Sci. Rep. 1980-03, 10 pp., https://ags.aer.ca/document/ESR/ESR_1980_03.pdf, 1980.

Burd, K., Tank, S. E., Dion, N., Quinton, W. L., Spence, C., Tanentzap, A. J., and Olefeldt, D.: Seasonal shifts in export of DOC and nutrients from burned and unburned peatland-rich catchments, Northwest Territories, Canada, Hydrol. Earth Syst. Sci., 22, 4455-4472, https://doi.org/10.5194/hess-22-4455-2018, 2018.

Burton, P. J.: Understanding spring wildfires in Canada's northern forests, Glob. Change Biol., 29, 5983–5985, https://doi.org/10.1111/gcb.16879, 2023.

Buscemi, S. and Plaia, A.: Model selection in linear mixed-effect models, AStA Adv. Stat. Anal., 104, 529-575, https://doi.org/10.1007/s10182-019-00359-z, 2020.

Canadian Council of Ministers of the Environment: Canadian water quality guidelines for the protection of aquatic life – mercury – inorganic mercury and methylmercury, report, 2003.

Carpino, O., Haynes, K., Connon, R., Craig, J., Devoie, É., and Quinton, W.: Long-term climate-influenced land cover change in discontinuous permafrost peatland complexes, Hydrol. Earth Syst. Sci., 25, 3301-3317, https://doi.org/10.5194/hess-25-3301-2021, 2021.

Connon, R. F., Quinton, W. L., Craig, J. R., and Hayashi, M.: Changing hydrologic connectivity due to permafrost thaw in the lower Liard River valley, NWT, Canada, Hydrol. Process., 28, 4163-4178, https://doi.org/10.1002/hyp.10206, 2014.

Dastoor, A., Wilson, S. J., Travnikov, O., Ryjkov, A., Angot, H., Christensen, J. H., et al.: Arctic atmospheric mercury: sources and changes, Sci. Total Environ., 839, 156213, https://doi.org/10.1016/j.scitotenv.2022.156213, 2022.

Eckhardt, B. W., and Moore, T. R.: Controls on dissolved organic carbon concentrations in streams, southern Quebec, Can. J. Fish. Aquat. Sci., 47, https://doi.org/10.1139/f90-173, 1990.

Ecosystem Classification Group: Ecological regions of the Northwest Territories – Taiga Plains, Dep. of Env. and Nat. Res., Gov. of the Nor. Ter., Yellowknife, NT, Canada, viii + 173 pp. + folded insert map, 2007.

Ensign, S. H., and Doyle, M. W.: Nutrient spiraling in streams and river networks, J. Geophys. Res. Biogeosci., 111, https://doi.org/10.1029/2005jg000114, 2006.

Evans, M., Warburton, J., and Yang, J.: Eroding blanket peat catchments: Global and local implications of upland organic sediment budgets, Geomorphology, 79, 45-57, https://doi.org/10.1016/j.geomorph.2005.09.015, 2006.

Frey, K. E., and Smith, L. C.: Amplified carbon release from vast West Siberian peatlands by 2100, Geophys. Res. Lett., 32, https://doi.org/10.1029/2004gl022025, 2005.

Frey, K. E., McClelland, J. W., Holmes, R. M., and Smith, L. C.: Impacts of climate warming and permafrost thaw on the riverine transport of nitrogen and phosphorus to the Kara Sea, J. Geophys. Res. Biogeosci., 112, https://doi.org/10.1029/2006jg000369, 2007.

Frey, K. E., and McClelland, J. W.: Impacts of permafrost degradation on arctic river biogeochemistry, Hydrol. Process., 23, 169–182, https://doi.org/10.1002/hyp.7196, 2009.

Gantner, N., Muir, D.C., Power, M., Iqaluk, D., Reist, J.D., Babaluk, J.A., Meili, M., Borg, H., Hammar, J., Michaud, W., Dempson, B., Solomon, K.R.: Mercury concentrations in landlocked Arctic char (Salvelinus alpinus) from the Canadian Arctic. Part II: influence of lake biotic and abiotic characteristics on geographic trends in 27 populations, Environ. Toxicol. Chem., 29, 633-643, https://doi.org/10.1002/etc.96, 2010.

Gindorf, S., Baptista-Salazar, C., Liem-Nguyen, V., Giesler, R., Mörth, C. M., and Jonsson, S.: Catchment properties as drivers of mercury speciation in streams and lakes across a sub-Arctic climate gradient, J. Geophys. Res. Biogeosci., 130, https://doi.org/10.1029/2024jg008661, 2025.

Godsey, S. E., Kirchner, J. W., and Clow, D. W.: Concentration–discharge relationships reflect chemostatic characteristics of US catchments, Hydrol. Process., 23, 1844-1864, https://doi.org/10.1002/hyp.7315, 2009.

Gómez-Gener, L., Hotchkiss, E. R., Laudon, H., and Sponseller, R. A.: Integrating discharge-concentration dynamics across carbon forms in a boreal landscape, Water Resour. Res., 57, https://doi.org/10.1029/2020wr028806, 2021.

Goodbrand, A., Westbrook, C. J., and Van Der Kamp, G.: Hydrological functions of a peatland in a Boreal Plains catchment, Hydrol. Process., 33, 562–574, https://doi.org/10.1002/hyp.13343, 2019.

Gordon, J., Quinton, W., Branfireun, B. A., and Olefeldt, D.: Mercury and methylmercury biogeochemistry in a thawing permafrost wetland complex, Northwest Territories, Canada, Hydrol. Process., 30, 3627-3638, 2 https://doi.org/10.1002/hyp.10911, 2016.

Government of Canada, Natural Resources Canada, Geological Survey of Canada, and Geological Survey of Canada - GSC Central Canada: Surficial geology map of Canada, 1:5 000 000, Natural Resources Canada, Federal Geospatial Platform [data set], https://osdp-psdo.canada.ca/dp/en/search/metadata/NRCAN-FGP-1-317ebf06-e053-b10f-6092-bfe0c1af8703, 2025.

Heginbottom, J. A., Dubreuil, M.-A., and Harker, P.: Canada, permafrost, in: The National Atlas of Canada, 5th ed., Natural Resources Canada, Geomatics Canada, MCR Series 4177, Natural Resources Canada, https://doi.org/10.4095/294672, 1995.

Hermosilla, T., Wulder, M. A., White, J. C., Coops, N. C., and Hobart, G. W.: Disturbance informed annual land cover classification maps of Canada's forested ecosystems for a 29-year Landsat time series, Can. J. Remote Sens., 44, 67-87, https://doi.org/10.1080/07038992.2018.1437719, 2018.

Hermosilla, T., Wulder, M. A., White, J. C., and Coops, N. C.: Land cover classification in an era of big and open data: Optimizing localized implementation and training data selection to improve mapping outcomes, Remote Sens. Environ., 268, 112780, https://doi.org/10.1016/j.rse.2021.112780, 2022.

Hinton, M. J., Schiff, S. L., and English, M. C.: Sources and flowpaths of dissolved organic carbon during storms in two forested watersheds of the Precambrian Shield, Biogeochemistry, 41, 175–197, https://doi.org/10.1023/a:1005903428956, 1998.

Hinzman, L. D., Bettez, N. D., Bolton, W. R., Chapin, F. S., Dyurgerov, M. B., Fastie, C. L., Griffith, B., Hollister, R. D., Hope, A., Huntington, H. P., Jensen, A. M., Jia, G. J., Jorgenson, T., Kane, D. L., Klein, D. R., Kofinas, G., Lynch, A. H., Lloyd, A. H., McGuire, A. D., Nelson, F. E., Oechel, W. C., Osterkamp, T. E., Racine, C. H., Romanovsky, V. E., Stone, R. S., Stow, D. A., Sturm, M., Tweedie, C. E., Vourlitis, G. L., Walker, M. D., Walker, D. A., Webber, P. J., Welker, J. M., Winker, K. S., and Yoshikawa, K.: Evidence and implications of recent climate change in northern Alaska and other arctic regions, Clim. Change, 72, 251-298, https://doi.org/10.1007/s10584-005-5352-2, 2005.

Houde, M., Krümmel, E. M., Mustonen, T., Brammer, J., Brown, T. M., Chételat, J., Dahl, P. E., Dietz, R., Evans, M., Gamberg, M., Gauthier, M.-J., Gérin-Lajoie, J., Hauptmann, A. L., Heath, J. P., Henri, D. A., Kirk, J., Laird, B., Lemire, M., Lennert, A. E., Letcher, R. J., Lord, S., Loseto, L., MacMillan, G. A., Mikaelsson, S., Mutter, E. A., O'Hara, T., Ostertag, S., Robards, M., Shadrin, V., Smith, M., Stimmelmayr, R., Sudlovenick, E., Swanson, H., Thomas, P. J., Walker, V. K., and Whiting, A.: Contributions and perspectives of Indigenous peoples to the study of mercury in the Arctic, Sci. Total Environ., 841, 156566, https://doi.org/10.1016/j.scitotenv.2022.156566, 2022.

Jackson, D.A.: Stopping rules in principal components analysis: a comparison of heuristical and statistical approaches, Ecology, 74, 2204-2214, https://doi.org/10.2307/1939574, 1993.

Julian, J. P., Doyle, M. W., Powers, S. M., Stanley, E. H., and Riggsbee, J. A.: Optical water quality in rivers, Water Resour. Res., 44, https://doi.org/10.1029/2007wr006457, 2008.

Kaiser, K., and Zech, W.: Rates of dissolved organic matter release and sorption in forest soils, Soil Sci., 163, 714-725, https://doi.org/10.1097/00010694-199809000-00005, 1998.

Kirk, J. L., and St. Louis, V. L.: Multiyear total and methyl mercury exports from two major sub-Arctic rivers draining into Hudson Bay, Canada, Environ. Sci. Technol., 43, 2254-2261, https://doi.org/10.1021/es803138z, 2009.

Krickov, I. V., Lim, A. G., Manasypov, R. M., Loiko, S. V., Shirokova, L. S., Kirpotin, S. N., Karlsson, J., and Pokrovsky, O. S.: Riverine particulate C and N generated at the permafrost thaw front: case study of western Siberian rivers across a 1700 km latitudinal transect, Biogeosciences, 15, 6867–6884, https://doi.org/10.5194/bg-15-6867-2018, 2018.

Kritzberg, E. S., Hasselquist, E. M., Škerlep, M., Löfgren, S., Olsson, O., Stadmark, J., Valinia, S., Hansson, L.-A., and Laudon, H.: Browning of freshwaters: consequences to ecosystem services, underlying drivers, and potential mitigation measures, Ambio, 49, 375-390, https://doi.org/10.1007/s13280-019-01227-5, 2020.

Kuznetsova, A., Brockhoff, P. B., and Christensen, R. H. B.: lmerTest package: tests in linear mixed effects models, J. Stat. Softw., 82, 1–26, https://doi.org/10.18637/jss.v082.i13, 2017.

Laudon, H., Berggren, M., Ågren, A., Buffam, I., Bishop, K., Grabs, T., Jansson, M., and Köhler, S.: Patterns and dynamics of dissolved organic carbon (DOC) in boreal streams: The role of processes, connectivity, and scaling, Ecosystems, 14, 880–893, https://doi.org/10.1007/s10021-011-9452-8, 2011.

McDonough, L. K., Andersen, M. S., Behnke, M. I., Rutlidge, H., Oudone, P., Meredith, K., O'Carroll, D. M., Santos, I. R., Marjo, C. E., Spencer, R. G. M., McKenna, A. M., and Baker, A.: A new conceptual framework for the transformation of groundwater dissolved organic matter, Nat. Commun., 13, 2153, https://doi.org/10.1038/s41467-022-29711-9, 2022.

Mitchell, C. P., Branfireun, B. A., and Kolka, R. K.: Spatial characteristics of net methylmercury production hot spots in peatlands, Environ. Sci. Technol., 42, 1010-1016, https://doi.org/10.1021/es0704986, 2008.

Mitchell, C. P., Branfireun, B. A., and Kolka, R. K.: Methylmercury dynamics at the upland-peatland interface: Topographic and hydrogeochemical controls, Water Resour. Res., 45, https://doi.org/10.1029/2008wr006832, 2009.

Moatar, F., Abbott, B. W., Minaudo, C., Curie, F., and Pinay, G.: Elemental properties, hydrology, and biology interact to shape concentration–discharge curves for carbon, nutrients, sediment, and major ions, Water Resour. Res., 53, 1270–1287, https://doi.org/10.1002/2016wr019635, 2017.

Moore, T. R., Knorr, K. H., Thompson, L., Roy, C., and Bubier, J. L.: The effect of long-term fertilization on peat in an ombrotrophic bog, Geoderma, 343, 176-186, https://doi.org/10.1016/j.geoderma.2019.02.034, 2019.

Natural Resources Canada: National Hydrometric Network Basin Polygons, Government of Canada [data set], 2022.

Nilsson, C., Polvi, L. E., and Lind, L.: Extreme events in streams and rivers in arctic and subarctic regions in an uncertain future, Freshw. Biol., 60, 2535-2546, https://doi.org/10.1111/fwb.12477, 2015.

Niu, L., Ye, B., Li, J., and Sheng, Y.: Effect of permafrost degradation on hydrological processes in typical basins with various permafrost coverage in Western China, Sci. China Earth Sci., 54, 615-624, https://doi.org/10.1007/s11430-010-4073-1, 2011.

O'Donnell, J., Douglas, T., Barker, A., and Guo, L.: Changing biogeochemical cycles of organic carbon, nitrogen, phosphorus, and trace elements in Arctic rivers, in: Arctic hydrology, permafrost and ecosystems, Springer International Publishing, Cham, 315–348, https://doi.org/10.1007/978-3-030-50930-9_11, 2021.

Olefeldt, D., and Roulet, N. T.: Effects of permafrost and hydrology on the composition and transport of dissolved organic carbon in a subarctic peatland complex, J. Geophys. Res. Biogeosci., 117, https://doi.org/10.1029/2011JG001819, 2012.

https://doi.org/10.5194/egusphere-2026-2199
Preprint. Discussion started: 12 May 2026

Olefeldt, D., Roulet, N., Giesler, R., and Persson, A.: Total waterborne carbon export and DOC composition from ten nested subarctic peatland catchments-importance of peatland cover, groundwater influence, and inter-annual variability of precipitation patterns, Hydrol. Process., 27, 2280–2294, https://doi.org/10.1002/hyp.9358, 2013.

Olefeldt, D., Persson, A., and Turetsky, M. R.: Influence of the permafrost boundary on dissolved organic matter characteristics in rivers within the Boreal and Taiga plains of western Canada, Environ. Res. Lett., 9, https://doi.org/10.1088/1748-9326/9/3/035005, 2014.

Olefeldt, D., and Roulet, N. T.: Permafrost conditions in peatlands regulate magnitude, timing, and chemical composition of catchment dissolved organic carbon export, Glob. Change Biol., 20, 3122–3136, https://doi.org/10.1111/gcb.12607, 2014.

Olefeldt, D., Heffernan, L., Jones, M. C., Sannel, A. B. K., Treat, C. C., and Turetsky, M. R.: Permafrost thaw in northern peatlands: rapid changes in ecosystem and landscape functions, in: Ecosystem collapse and climate change, Springer International Publishing, 27–67, https://doi.org/10.1007/978-3-030-71330-0_3, 2021.

Orlova, J., Amiri, F., Bourgeois, A. K., Buttle, J. M., Cherlet, E., Cuss, C. W., Devito, K. J., Emelko, M. B., Floyd, W. C., Foster, D. E., Hutchins, R. H. S., Jamieson, R., Johnson, M. S., McSorley, H. J., Silins, U., Tank, S. E., Thompson, L. M., Webster, K. L., Williams, C. H. S., and Olefeldt, D.: Composition of stream dissolved organic matter across Canadian forested ecozones varies in three dimensions linked to landscape and climate, Water Resour. Res., 60, https://doi.org/10.1029/2023wr035196, 2024.

Orlova, J.: Fifty Shades of Brown: Variability of dissolved organic matter in forested streams across spatial and temporal scales, Ph.D. thesis, Department of Renewable Resources, University of Alberta, Canada, 195 pp., https://doi.org/10.7939/r3-r729-gb10, 2024.

Pardo, L. H., Green, M. B., Bailey, S. W., McGuire, K. J., and McDowell, W. H.: Identifying controls on nitrate sources and flowpaths in a forested catchment using a hydropedological framework, J. Geophys. Res. Biogeosci., 127, https://doi.org/10.1029/2020jg006140, 2022.

Pettersson, K., Boström, B., and Jacobsen, O. S.: Phosphorus in sediments-speciation and analysis, Hydrobiologia, 170, 91-101, https://doi.org/10.1007/bf00024900, 1988.

Pilgrim, D. H., Cordery, I., and Baron, B. C.: Effects of catchment size on runoff relationships, J. Hydrol., 58, 205-221, https://doi.org/10.1016/0022-1694(82)90035-x, 1982.

Previdi, M., Smith, K. L., and Polvani, L. M.: Arctic amplification of climate change: a review of underlying mechanisms, Environ. Res. Lett., 16, https://doi.org/10.1088/1748-9326/ac1c29, 2021.

Prijac, A., Gandois, L., Taillardat, P., Bourgault, M.-A., Riahi, K., Ponçot, A., Tremblay, A., and Garneau, M.: Hydrological connectivity controls dissolved organic carbon exports in a peatland-dominated boreal catchment stream, Hydrol. Earth Syst. Sci., 27, 3935–3955, https://doi.org/10.5194/hess-27-3935-2023, 2023.

Quinton, W. L., Hayashi, M., and Chasmer, L. E.: Peatland hydrology of discontinuous permafrost in the Northwest Territories: overview and synthesis, Can. Water Resour. J., 34, 311-328, https://doi.org/10.4296/cwrj3404311, 2009.

https://doi.org/10.5194/egusphere-2026-2199
Preprint. Discussion started: 12 May 2026

Quinton, W. L., Hayashi, M., and Chasmer, L. E.: Permafrost-thaw-induced land-cover change in the Canadian subarctic: Implications for water resources, Hydrol. Process., 25, 152-158, https://doi.org/10.1002/hyp.7894, 2011.

Ramchunder, S. J., Brown, L. E., Holden, J., and Langton, R.: Spatial and seasonal variability of peatland stream ecosystems, Ecohydrology, 4, 577–588, https://doi.org/10.1002/eco.189, 2011.

Riscassi, A. L., Hokanson, K. J., and Scanlon, T. M.: Streamwater particulate mercury and suspended sediment dynamics in a forested headwater catchment, Water Air Soil Pollut., 220, 23-36, https://doi.org/10.1007/s11270-010-0731-3, 2011.

Robinson, S. D., and Moore, T. R.: The influence of permafrost and fire upon carbon accumulation in high boreal peatlands, Northwest Territories, Canada, Arct. Antarct. Alp. Res., 32, 155-166, https://doi.org/10.1080/15230430.2000.12003351, 2000.

Rose, L. A., Karwan, D. L., and Godsey, S. E.: Concentration–discharge relationships describe solute and sediment mobilization, reaction, and transport at event and longer timescales, Hydrol. Process., 32, 2829-2844, https://doi.org/10.1002/hyp.13235, 2018.

Schiff, S., Aravena, R., Mewhinney, E., Elgood, R., Warner, B., Dillon, P., and Trumbore, S.: Precambrian shield wetlands: hydrologic control of the sources and export of dissolved organic matter, Clim. Change, 40, 167–188, https://doi.org/10.1023/a:1005496331593, 1998.

Shewan, R. L.: Landscape influences on downstream concentrations of mercury, methylmercury, and dissolved organic carbon in permafrost peatland catchments, MSc. thesis, Department of Renewable Resources, University of Alberta, Canada, 93 pp., https://doi.org/10.7939/r3-hfk7-b706, 2024.

Shogren, A. J., Zarnetske, J. P., Abbott, B. W., Iannucci, F., Frei, R. J., Griffin, N. A., and Bowden, W. B.: Revealing biogeochemical signatures of Arctic landscapes with river chemistry, Sci. Rep., 9, 12894, https://doi.org/10.1038/s41598-019-49296-6, 2019.

Shrestha, N. K., and Wang, J.: Predicting sediment yield and transport dynamics of a cold climate region watershed in changing climate, Sci. Total Environ., 625, 1030-1045, https://doi.org/10.1016/j.scitotenv.2017.12.347, 2018.

Smith, S. L., O'Neill, H. B., Isaksen, K., Noetzli, J., and Romanovsky, V. E.: The changing thermal state of permafrost, Nat. Rev. Earth Environ., 3, 10–23, https://doi.org/10.1038/s43017-021-00240-1, 2022.

St. Louis, V. L., Rudd, J. W., Kelly, C. A., Beaty, K. G., Bloom, N. S., and Flett, R. J.: Importance of wetlands as sources of methyl mercury to boreal forest ecosystems, Can. J. Fish. Aquat. Sci., 51, 1065-1076, https://doi.org/10.1139/f94-106, 1994.

Staniszewska, K. J., Reyes, A. V., and Cooke, C. A.: Glacial erosion drives high summer mercury exports from the Yukon river, Canada, Environ. Sci. Technol. Lett., 10, 1117-1124, https://doi.org/10.1021/acs.estlett.3c00427, 2023.

Stankevicius, J., Pietroniro, A., Zhou, Q., and Connon, R.: A climatological approach to predicting water level of Great Slave Lake, Can. Water Resour. J., 50, 223-235, https://doi.org/10.1080/07011784.2025.2519131, 2025.

Sutherland, C., Hare, D., Johnson, P. J., Linden, D. W., Montgomery, R. A., and Droge, E.: Practical advice on variable selection and reporting using Akaike information criterion, Proc. R. Soc. B, 290, 2007, https://doi.org/10.1098/rspb.2023.1261, 2023.

https://doi.org/10.5194/egusphere-2026-2199
Preprint. Discussion started: 12 May 2026

Thompson, L. M., Low, M., Shewan, R., Schulze, C., Simba, M., Sonnentag, O., Tank, S.E., Olefeldt, D.: Concentrations and yields of mercury, methylmercury, and dissolved organic carbon from contrasting catchments in the discontinuous permafrost region, western Canada, Water Resour. Res., 59, https://doi.org/10.1029/2023wr034848, 2023a.

Thompson, L. M., Kuhn, M. A., Winder, J. C., Braga, L. P. P., Hutchins, R. H. S., Tanentzap, A. J., St. Louis, V. L., and Olefeldt, D.: Controls on methylmercury concentrations in lakes and streams of peatland-rich catchments along a 1700 km permafrost gradient, Limnol. Oceanogr., 68, 583–597, https://doi.org/10.1002/lno.12296, 2023b.

Thompson, L. M., Shewan, R., Mangal, V., Harris, L. I., Cheng, C. H., Braga, L. P. P., Kolmakova, O., Tanentzap, A. J., Knorr, K. H., Kuhn, M. A., Haugk, C., Azaroff, A., Jonsson, S., St. Louis, V. L., Lehnherr, I., Quinton, W. L., Sonnentag, O., and Olefeldt, D.: Production of Methylmercury in Peatlands Following Permafrost Thaw Increases along a Trophic Gradient, Environ. Sci. Technol., 59, 19457–19467, https://doi.org/10.1021/acs.est.5c04510, 2025.

Tiwari, T., Sponseller, R. A., and Laudon, H.: The emerging role of drought as a regulator of dissolved organic carbon in boreal landscapes, Nat. Commun., 13, https://doi.org/10.1038/s41467-022-32839-3, 2022.

Tokarsky, O.: Hydrogeology of the Mount Watt area, Alberta, Research Council of Alberta, RCA/AGS Earth Sci. Rep. 1972-03, 13 pp., https://ags.aer.ca/publications/ESR_1972_03.html, 1972.

Vorobyev, S. N., Pokrovsky, O. S., Serikova, S., Manasypov, R. M., Krickov, I. V., Shirokova, L. S., Lim, A., Kolesnichenko, L. G., Kirpotin, S. N., and Karlsson, J.: Permafrost boundary shift in Western Siberia may not modify dissolved nutrient concentrations in rivers, Water, 9, 985, https://doi.org/10.3390/w9120985, 2017.

Wagner, S., Fair, J. H., Matt, S., Hosen, J. D., Raymond, P., Saiers, J., Shanley, J. B., Dittmar, T., and Stubbins, A.: Molecular Hysteresis: Hydrologically Driven Changes in Riverine Dissolved Organic Matter Chemistry During a Storm Event, J. Geophys. Res. Biogeosci., 124, 759–774, https://doi.org/10.1029/2018JG004817, 2019.

Wang, T., Hamann, A., Spittlehouse, D., and Carroll, C.: Locally downscaled and spatially customizable climate data for historical and future periods for North America, PLoS One, 11, https://doi.org/10.1371/journal.pone.0156720, 2016.

Walvoord, M. A., and Kurylyk, B. L.: Hydrologic impacts of thawing permafrost-A review, Vadose Zone J., 15, https://doi.org/10.2136/vzj2016.01.0010, 2016.

Water Survey of Canada: Environment and Climate Change Canada Hydrometric Data, Government of Canada [data set], 2025.

Wig, E., Schaefer, K., Michaelides, R., Chen, R., Clayton, L. K., Fager, B., Huang, L., Parsekian, A. D., Zebker, H., Zhang, Y., and Zhao, Y.: Permafrost Dynamics Observatory: 3. remote sensing big data for the active layer, soil moisture, and greening and browning, Earth Space Sci., 12, https://doi.org/10.1029/2024ea003725, 2025.

Wright, S. N., Thompson, L. M., Olefeldt, D., Connon, R. F., Carpino, O. A., Beel, C. R., and Quinton, W. L.: Thaw-induced impacts on land and water in discontinuous permafrost: A review of the Taiga Plains and Taiga Shield, northwestern Canada, Earth-Sci. Rev., 232, https://doi.org/10.1016/j.earscirev.2022.104104, 2022.