Supporting Information

Potential for shoreline recession to accelerate pollutant fluxes across the groundwater-coastal water interface

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S1. Sediment extraction methods

Ammonium oxalate and sodium dithionite sediment extractions were conducted on select sediments samples collected in 2015 and 2020 to characterize different Fe-bearing solid phase pools. For the sodium dithionite extraction, 4 g of sediment samples was placed in a 250 mL centrifuge bottle and 40 mL of 0.3 M Na-citrate solution and 5 mL of 1 M $NaHCO_3$ solution were added (Mehra, 1958). The solution was treated in a water bath at 80°C and 1 g of solid $Na_2S_2O_4$ was added to flocculate the sample, after which the solution was stirred continuously for 1 min and then occasionally for a total of 15 min. The solution was then centrifuged at 2000 rpm for 5 minutes, after which the clear supernatant was decanted, filtered and analyzed for dissolved Fe using flame atomic absorption spectroscopy (FAAS, Agilent 200 Series). For the ammonium oxalate extraction, 1 g of sediment sample was placed in a 250 mL centrifuge bottle, 40 mL of acid oxalate solution was added and then it was placed in mechanical shaker for 4 hour in the dark (McKeague and Day, 1966). The solution was then centrifuged at 2400 rpm for 10 minutes. The clear supernatant solution was then decanted, filtered and analyzed for dissolved Fe using FAAS.

S2. Numerical model set up

Wave set-up approach has been shown to represent the main effects of waves on groundwater flow dynamics while reducing computational requirements(Robinson et al., 2014; Xin et al., 2010). Using this approach, the time-varying specified heads applied along the lake boundary (BC Figure 3) were calculated using an empirical wave setup formula developed by Nielsen(Nielsen, 2009) and given as:

$$\overline{\eta} = \frac{0.4H_{rms}}{1+10\dfrac{D+\overline{\eta}}{H_{rms}}} \quad (1)$$

where η (m) is the increase in water level above the still water level due to wave setup; H_{rms} (m) is the offshore root mean square wave height obtained from the Fisheries and Ocean Canada wave buoy (Figure 2b); and D (m) is the distance from the sediment water interface to the still water level and is a function of location across the beach face. Submerged nodes along the lake boundary were assigned a hydrostatic pressure corresponding to the wave setup profile. This was implemented using a modified form of the periodic boundary condition (PBC) package(Post, 2011) to allow a time-varying moving interface to be implemented. Nodes landward of the wave setup point along the lakeward boundary were represented as a no-flow boundary.

S3. PO_4-P and NO_3-N flux calculations

A steady state groundwater flow model was used to simulate the water flux directed towards the lake. The PO_4-P and NO_3-N fluxes near the shoreline were estimated by multiplying the simulated groundwater flux across a vertical line near the shoreline by field measured PO_4-P and NO_3-N concentrations (interpolated to a depth of 3 m below beach face). This calculation was performed for the simulated groundwater flux in 2014, 2015 and 2015 and for field measured PO_4-P and NO_3-N concentrations in each of these years with the location of the vertical line at x = 120.3 m in 2014 and 2015 and x = 88.7 m in 2020. The limitation of this calculation is that it does not consider that the measured PO_4-P and NO_3-N concentrations may be modified by dilution by surface water at shallow depth below the groundwater-lake interface.

S4. Correlation between NO_3-N and Electrical Conductivity (EC).

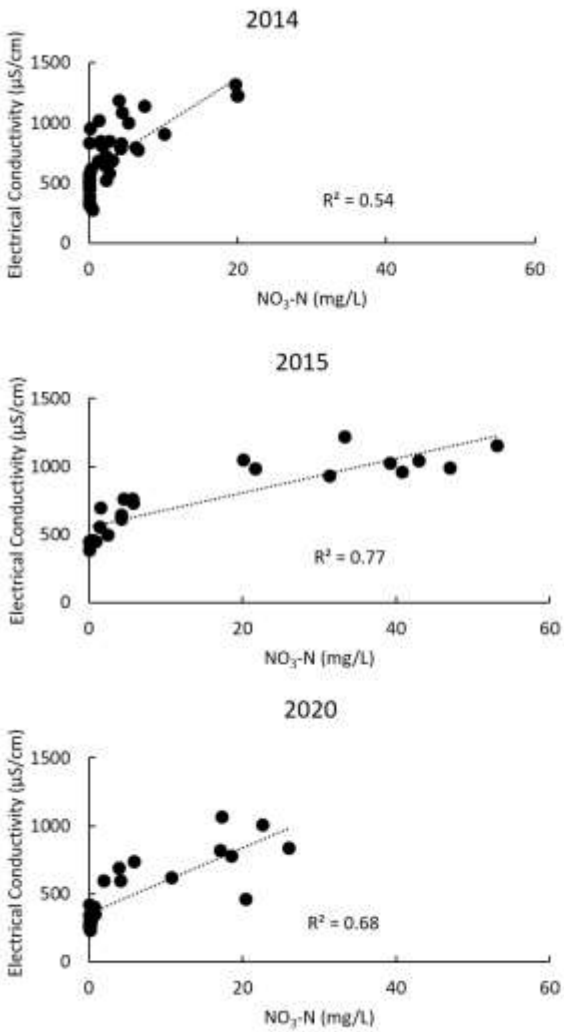

Figure S1. Correlation between NO_3-N and electrical conductivity (EC) in 2014, 2015 and 2020.

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