Base and event-flow hydrologic and biogeochemical connectivity in a fen-stream transition in the central Hudson Bay Lowland

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Introduction

The hydrological and biogeochemical role of riparian areas of the Hudson James Bay Lowlands (HJBL) the world's second largest peatland complex (Riley, 2011), are unknown. The riparian areas of second order and higher streams are drier, have taller trees, and have less soil organic matter than the surrounding bogs and fens. These differences have important implications for the near stream hydrology.

As part of a broader assessment of the hydrology and biogeochemistry of the HJBL, this study sought to:

- Clarify the influence of the riparian zone on the connectivity between a fen and a second order stream
- Quantify the flux of water and solutes (specifically dissolved organic carbon (DOC) and methylmercury (MeHg)) between the fen and the stream.

Study Site

Figure 1: The study site is on Tributary 5 within the watershed of the Nayshkootayaow River, a tributary of the Attawapiskat River ~12km from the DeBeers Victor Diamond Mine (52.83 N, 83.93 W).

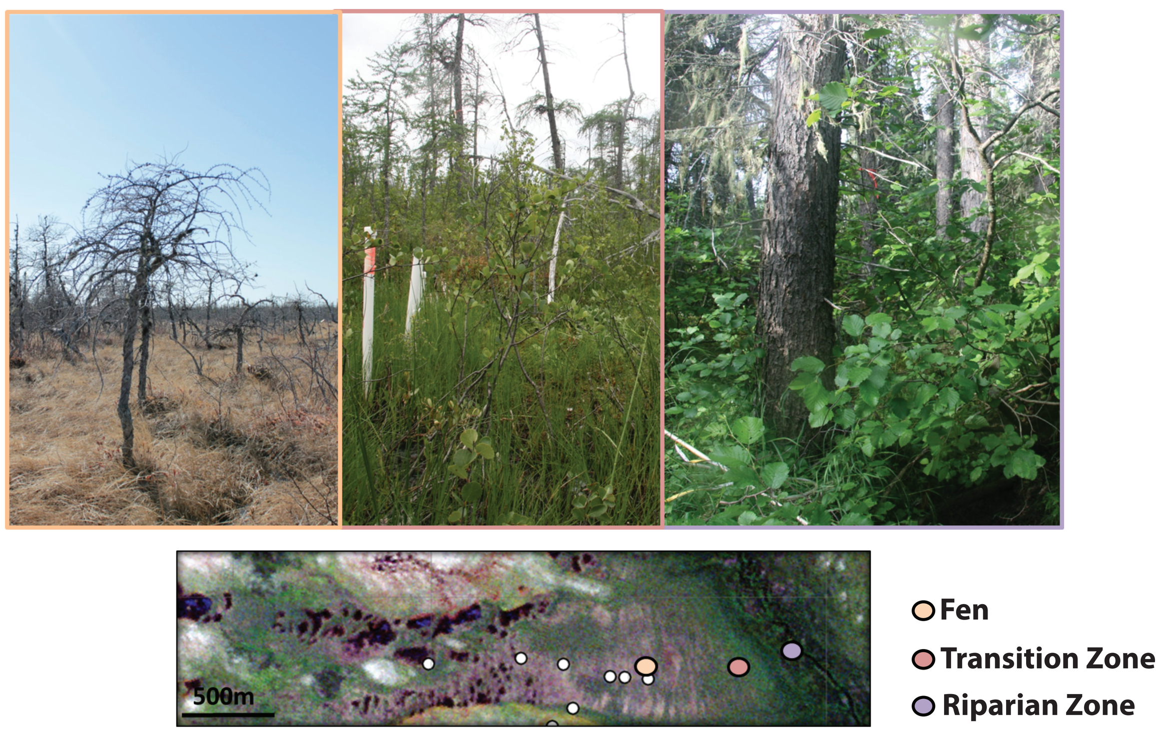

Figure 2: Shows the transition from the fen down to the narrow riparian forest that borders Tributary 5. The vegetation reflects changes in hydrology and biogeochemistry in the riparian zone. In the fen there is an accumulation of ~2m of peat, overlying low permeability marine sediments, while only ~40cm have accumulated in the riparian zone.

Methods

Field reconnaissance revealed the presence of small rivulets/soil pipes in the riparian zone, which were hypothesized to be an important connection between the fen and the stream.

- Continuous record of flow using v-notch weirs and flumes fitted with pressure transducers.
- Outlets were sampled on an event basis to capture important stormflow solute dynamics including methylmercury (MeHg) (e.g. Babiarz et al. 1998). This represents the first event-flow sampling of MeHg in this environment. The water samples were analyzed for major ions, water isotopes, DOC, and a subset for MeHg and Total mercury (THg).

Results and Discussion

Tributary 5 is incised down through the peatland into the marine sediments, exposing low permeability sediments close to the surface. As there is only a thin organic layer overlying these sediments, most of the flow is in the form of localized surface and subsurface drainage; small rivulets and soil pipes. As shown by Figure 3, discharge from the soil pipes is dominated by storm events in the mid to late fall when antecedent conditions are wet.

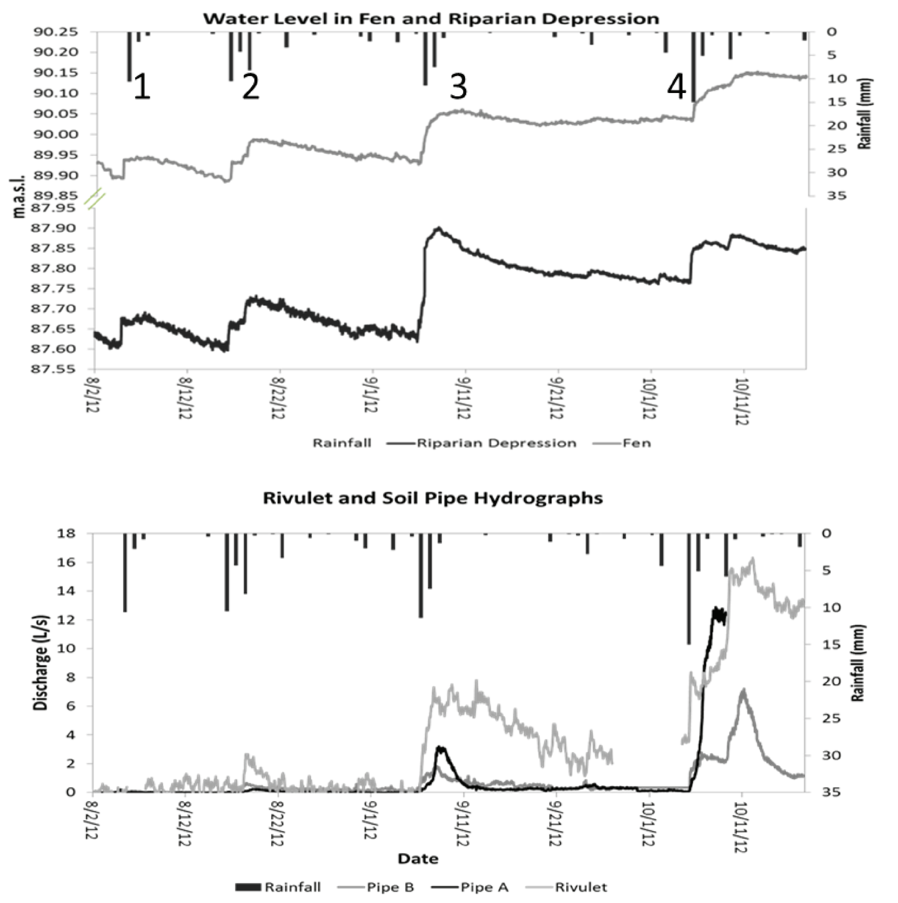

Figure 3: Variations in water table for the riparian depression and the fen compared to the hydrographs of the rivulet and 2 soil pipes. Shows how the riparian depression is more hydrologically responsive than the fen. Furthermore, although storm #3 has the greatest rainfall the run-off is more for storm #4 because there is less storage available in the fen and riparian depression by the end of the season.

Water Table vs Discharge in a Rivulet and Soil Pipe

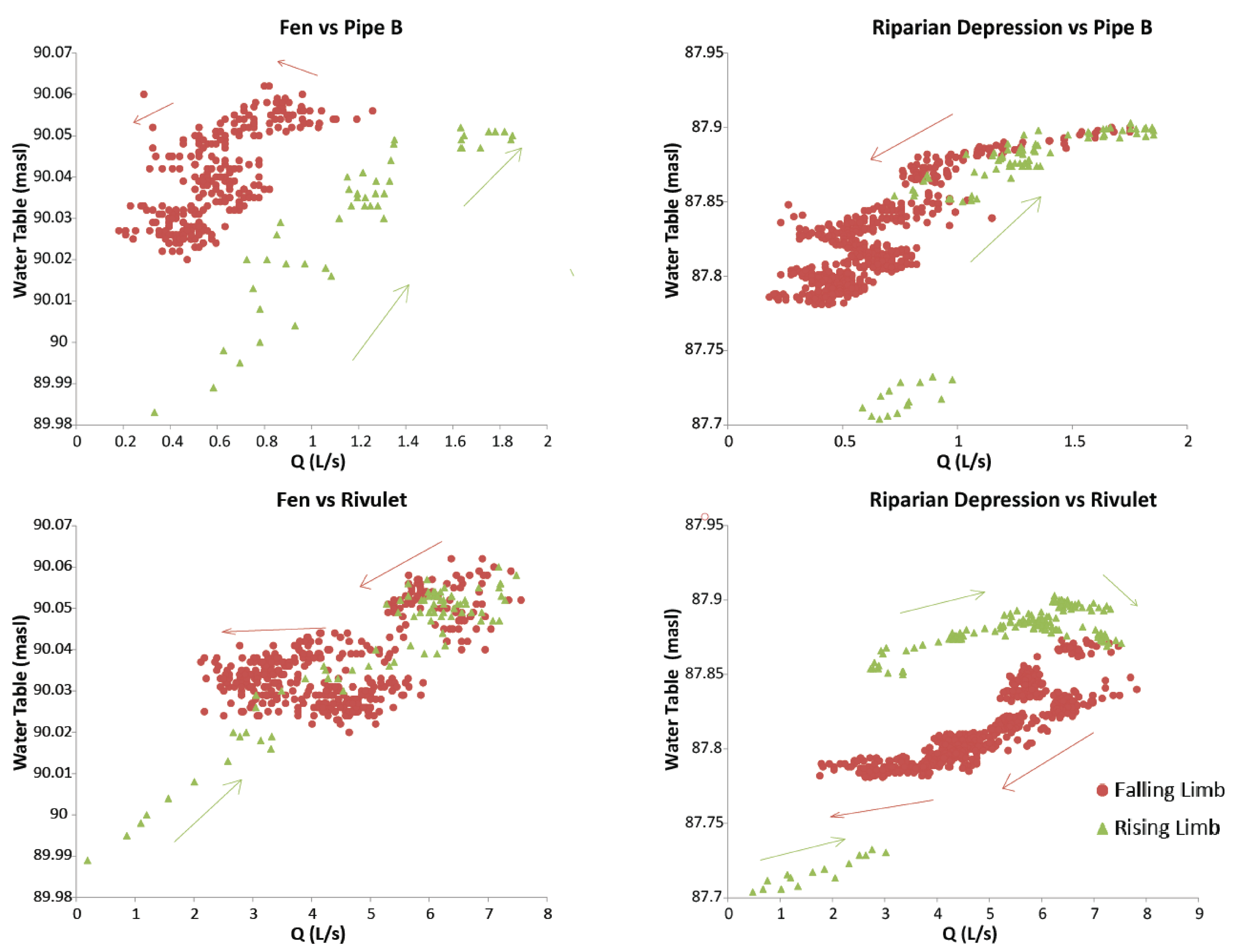

Figure 4: compares the response of the rivulet and one of the soil pipes to changes in water table in the fen and in the riparian depression. The data plotted is from storm #3 in September. These plots of discharge vs. water table show more pronounced hysteresis between soil pipe B and the fen compared to the rivulet, reflecting the greater connectivity of the rivulet to the fen. Furthermore, Fen vs. Rivulet shows how the water table plateaus on the falling limb while the discharge continues to drop.

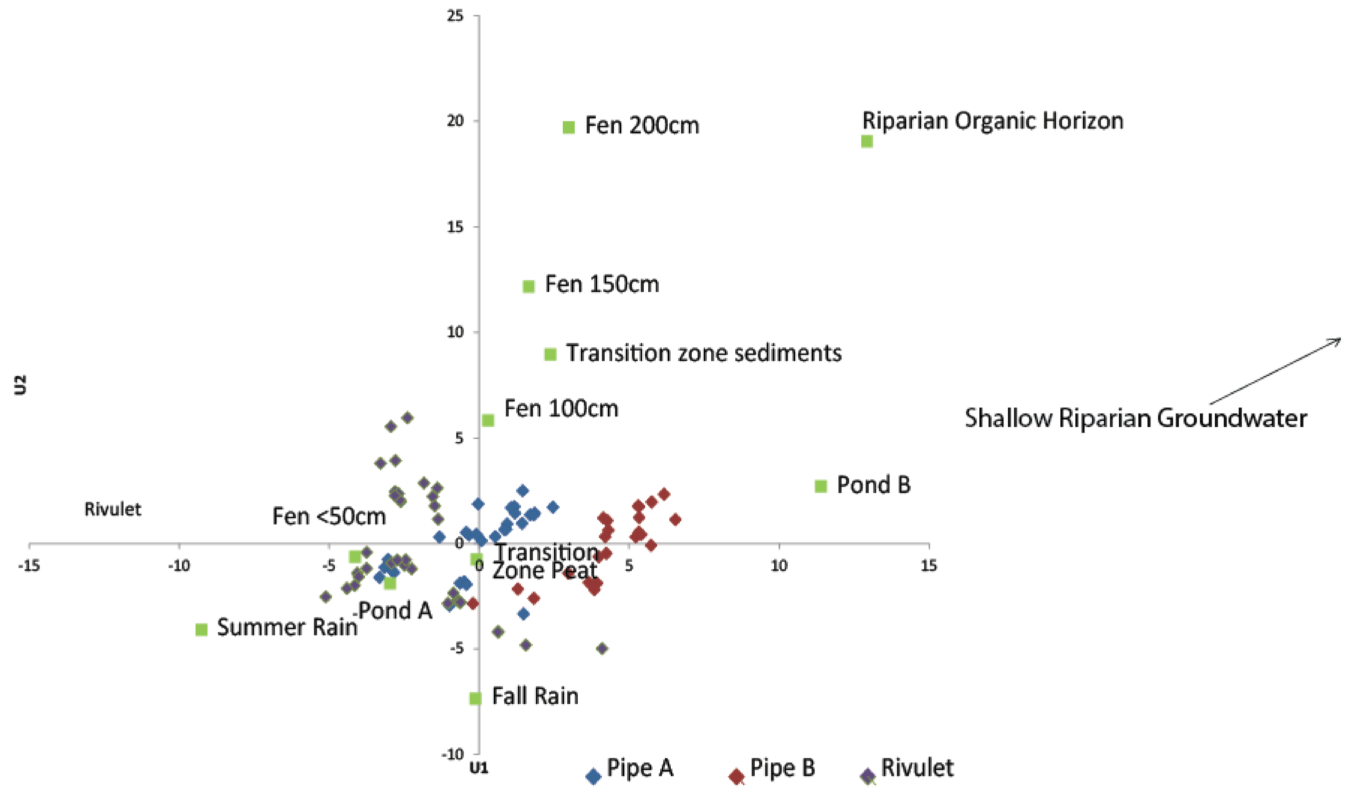

Figure 5: shows the mixing U-Space defined by the using the tracers DOC, EC, O18, H2, Mg2+ and Cl- used in a principal componant analysis on the rivulet and pipe data. U1 correlates strongly with DOC, Cl-, O18 and H2 while U2 correlates with EC and Mg2+. Field observation suggests that most of the water feeding into the soil pipes comes from the riparian organic horizon. This organic horizon is a mixing zone for shallow groundwater, water arriving from the fen, and organic matter from the riparian vegetation. Shallow groundwater in the organic horizon impacts riparian biogeochemistry by contributing solutes to an otherwise dilute environment.

Analysis shows that pore water and surface waters in the riparian area are significantly more enriched in DOC and MeHg than in the adjacent fen.

- Median concentrations of DOC in the riparian zone and adjacent fen are 24 and 9 mg/L, respectively.
- MeHg concentrations in the riparian area are an order of magnitude higher than in the fen (0.27 and 0.02 ng/L respectively).

Conclusions

As Woo and diCenzo (1988) found in the southern HJBL, pipeflow is a significant contributor to run-off in this environment. Under dry conditions the riparian area dampens the event response of the fen, but satisfaction of the storage deficit in the riparian area results in an amplified storm response in the outlets relative to the fen. Compared to the fen, the rivulet and pipes return to baseflow more quickly, while the fen water tables stay high, partially disconnecting the fen from the streams between storm events. Finally, the mixing of waters and contribution of riparian organic matter, combined with other hydrogeomorphologic features of the riparian area, make it a MeHg hotspot compared to the dilute fen.

References and Acknowledgements

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