Active Channel Loss, Reed Canary Grass Expansion, and Nutrient Enriched Groundwater in the Lower Chippewa River in West-central Wisconsin

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Abstract

Maps constructed from aerial photographs dating to 1938 along a 50-km section of the Lower Chippewa River (LCR) in western Wisconsin document a decline of active-channel area exceeding 25%. This loss in channel area has occurred despite no detectable change in stream hydrology. Much of the loss instead seems due to the stabilization of lateral bars by reed canary grass (RCG), a significant invasive wetland species in the Upper Midwest. GPS surveys of RCG patches along the river indicate that RCG-stabilized bars account for as much as 100% of the main channel loss that occurred during the main period of RCG invasion. Why RCG invaded the channel during this time period is unknown, but one hypothesis is that it is coincident with the expansion of center-pivot irrigation on nearby cropland, which led to groundwater discharge into the river enriched in plant-available nutrients. As a first step in testing this hypothesis, we collected water samples during the summer of 2015 at six different times from six locations along the river where extensive monocultures of RCG exist. At each location we collected a river sample from mid channel and a groundwater sample from a hand-excavated pit along the riverbank. Samples were then analyzed at the county health department lab for nitrate and phosphorus concentrations. Results indicate that groundwater flowing toward the river is generally enriched in nitrates and phosphorus compared to the river, consistent with the hypothesis that groundwater enriched with agricultural nutrients is promoting RCG growth along the LCR.

Introduction

Reed Canary Grass (*Phalaris arundinacea*) (RCG) is considered by many to be an invasive species in fluvial environments. We are interested in studying the influence of RCG on water quality, aquatic life, nutrient uptake, and overall health of the lower Chippewa River (LCR) in western central Wisconsin (Figure 1). Previous research shows RCG is found extensively along the LCR (Figure 2) and has narrowed channel width (Faulkner 2014). Extensive RCG monocultures appear along the banks of the LCR coincidentally with the expansion of center pivot irrigation (both spatially and temporarily) on adjacent uplands and stream terraces (Figure 3). Previous research also shows a correlation between available nutrients and RCG growth and expansion rates -- "An increased nutrient input strongly stimulates the growth of *Phalaris arundinacea*'biomass" -- RCG takes up nutrients that would otherwise end up in surface water bodies like the LCR (Polechonska and Klink 2014). Our hypothesis is that groundwater enriched in agricultural nutrients, delivered to river banks via baseflow, is the source of excess nutrients which fuels RCG expansion in the LCR; and in turn, RCG uptakes nutrients that would otherwise pollute the LCR.

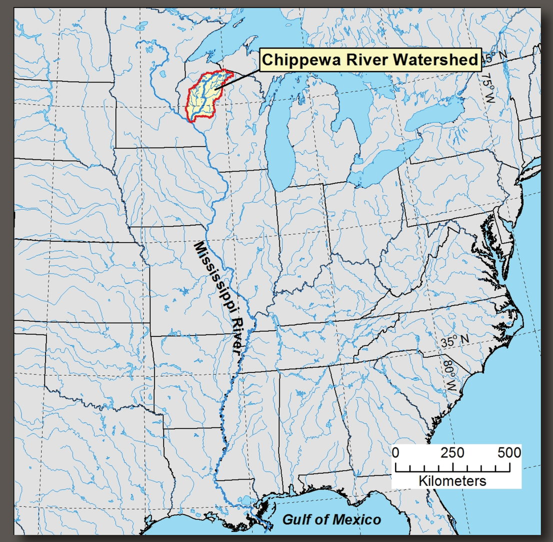

Figure 1. RCG study area. (Faulkner 2015).

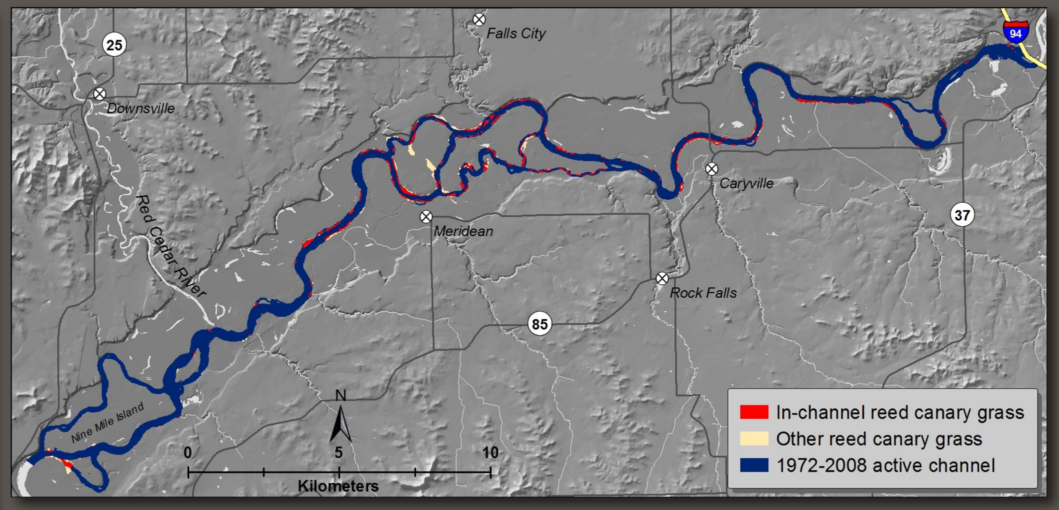

Figure 2. Locations where RCG was the dominant plant in the study area (Faulkner 2014).

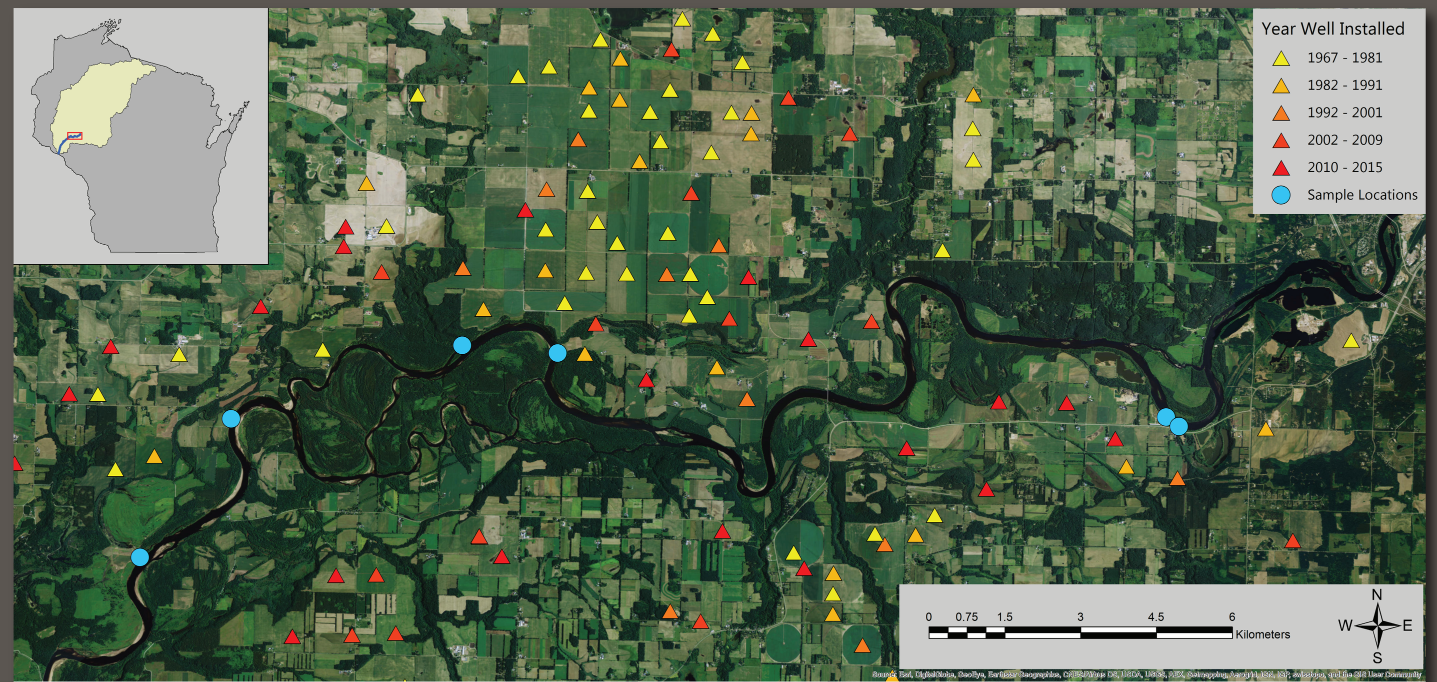

Figure 3. Our six sampling sites were located along a 33 km section of river containing abundant RCG. Farmland adjacent to this section of the river is irrigated by center pivot irrigation systems, depicted as triangles on the above map.

Methods

Six locations along the LCR were selected for water sampling based on the presence of extensive RCG monocultures and ease of access. Two water samples were collected from each site, six times during the summer of 2015. At each site, one water sample was collected from the channel and the other from the river bank where overbank and point bar deposits intersect (Figures 4 and 5). Water samples from the channel were collected at least 1 m from the bank (in-current). Water samples were collected from the bank from pits hand-excavated to a depth of .25-1.5 m deep until standing water was encountered. Water samples were collected using 250 mL sterilized Nalgene bottles. All 72 samples were submitted to the Eau Claire County Health Department for analysis of P and NO_3 content. Lab testing for P was 4500 P.E. Ascorbic Acid Method and 4500 NO_3 Nitrate Electrode Method for NO_3.

Figure 4 (left) Hand-excating a pit for bank sampling at site.

Figure 5 (above) Surface water sample (6A) and groundwater sample (6B).

Results

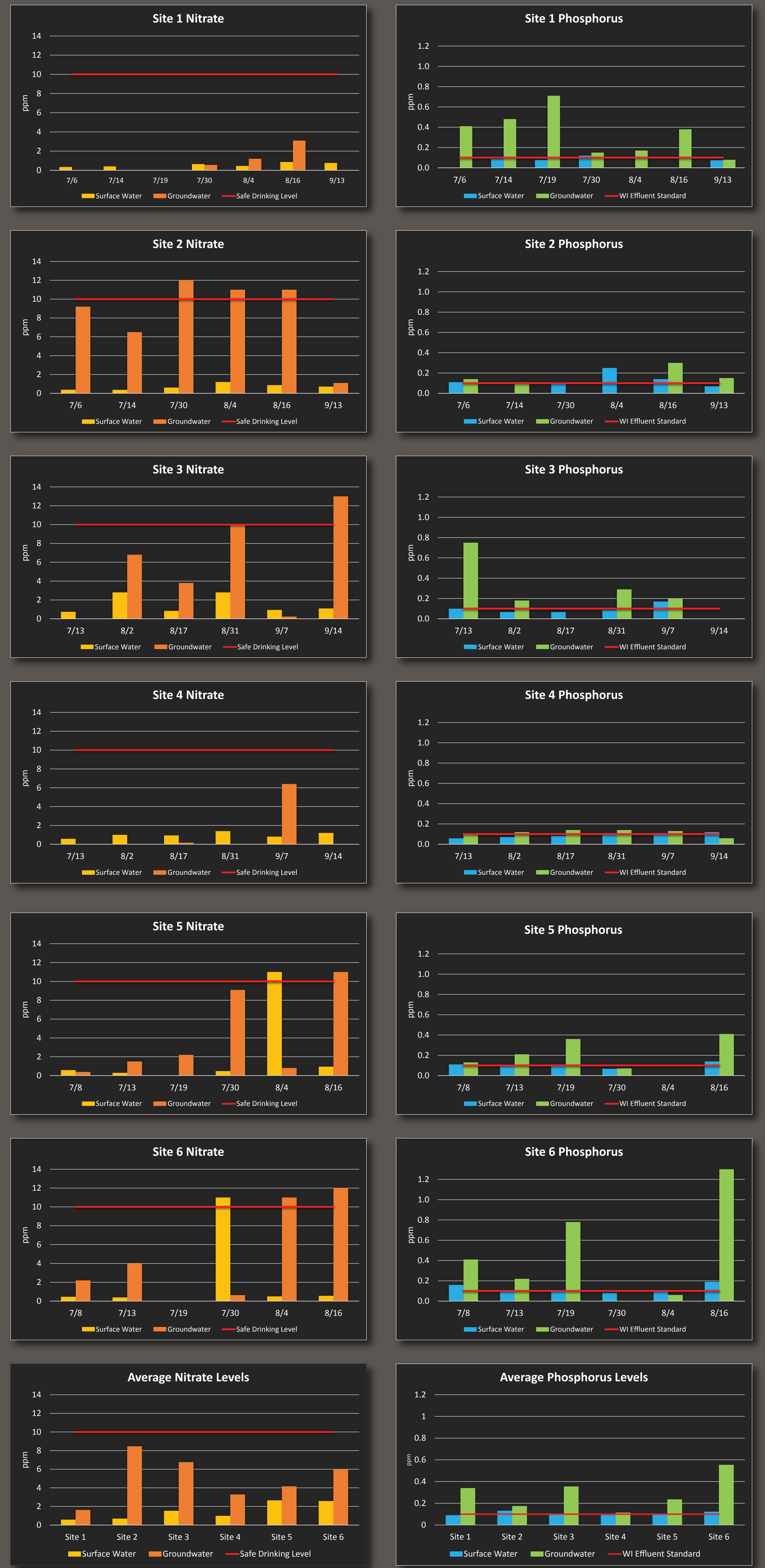

Figure 6. The graphs above display data from samples collected July through September, 2015. The red lines in both graphs indicate governmental (federal and state) standards for NO_3 and P. The NO_3 graphs' red line indicates the safe drinking level the US Environmental Protection Agency established for the nation. The P graphs indicate the Wisconsin Effluent Standard, which is the threshold for P surface water runoff in Wisconsin. There is no drinking water standard for P, as it is naturally occurring in the environment. We included these standards as a basis for reference. Overall, the groundwater samples had higher concentrations of nutrients than the adjacent surface water.

Discussion

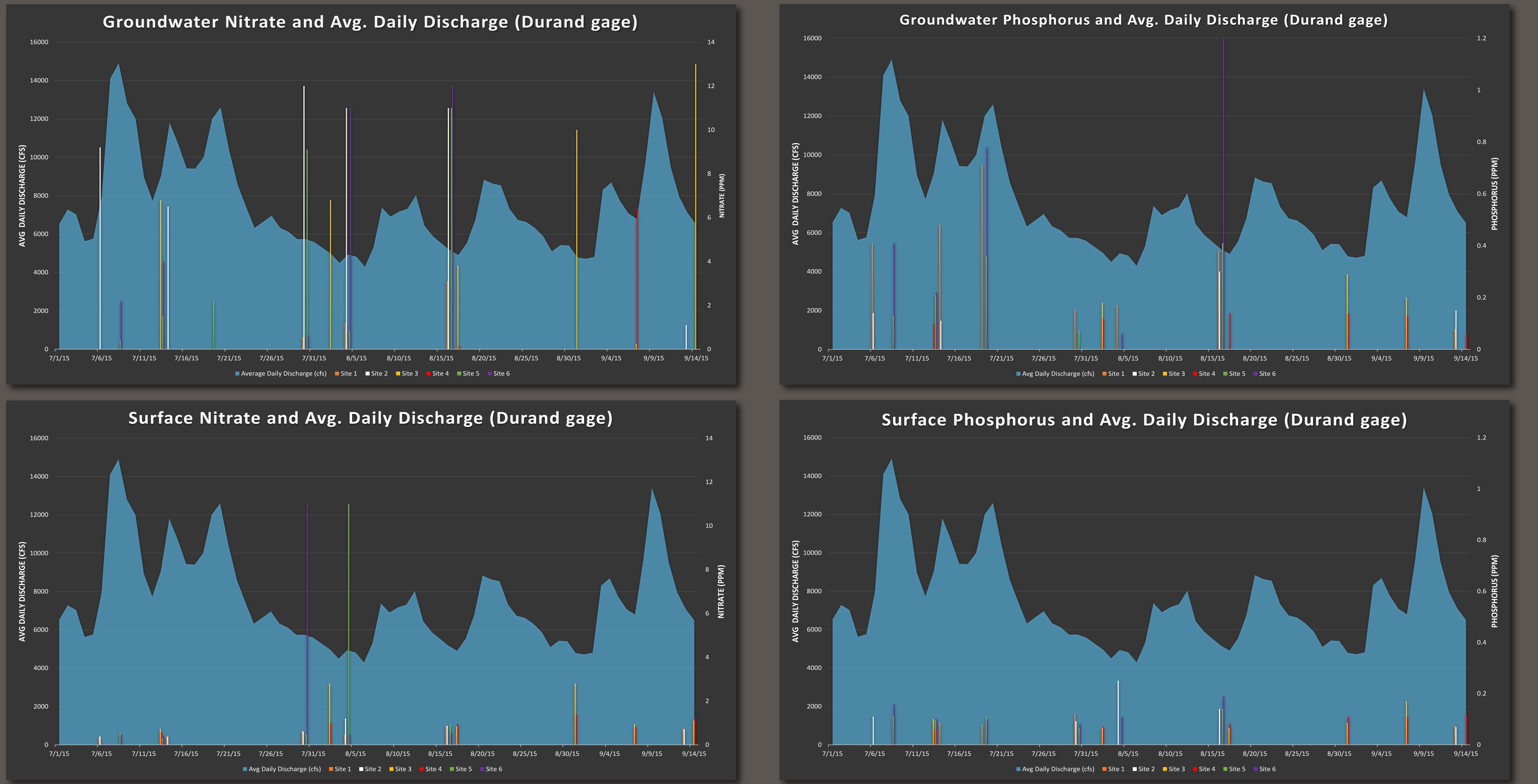

Figure 7. The above graphs depict relationships between nutrient concentrations and discharge. The discharge data was obtained from the USGS at the Durand gage, approx. 19 km downstream of the study area. With only a few exceptions, the graphs display that the nutrient concentrations were, by and large, much higher in the groundwater samples than in the surface water, regardless of discharge. We can only speculate why one samples from 7/31/15 and one sample from 8/5/15 show the opposite result of the other samples. We speculate that there was an error in the documentation of the sample somewhere along the process. The graphs provide preliminary evidence of excess nutrient infiltration into the soil, which is likely being transported through the groundwater system to the river's edge.

Conclusion

We were able to detect NO_3 and P using our sampling method. Water samples collected from the banks show elevated levels of NO_3 and P compared to samples from the river channel. Excess nutrients in bank samples could be from agricultural fields surrounding the LCR, via groundwater baseflow, but further research is required to confirm that. A correlation between low discharge and high nitrate levels appeared in the groundwater samples. Conversely, a correlation between high discharge and high phosphorus levels appeared in the groundwater samples. The hypothesis of RCG expansion due to groundwater nutrient enrichment is supported by our results and discussion.

Future Research

Future research will depend on improved data collection methods. We will need:

- More samples collected at more sample site locations (some where RCG is present and some where RCG is absent). More water sampling data will allow us to more rigorously test our hypothesis using spatial statistical methods.
- Improved bank sampling method (hand-excavated pits do not appear sufficient to consistently sample baseflow regardless of LCR discharge). Perhaps monitoring wells of some kind would be better than hand-excavated pits.
- To collect all water samples on same days to mitigate variations in LCR discharge.

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Limitations

- All sites were not sampled on the same day so LCR discharge varied throughout sample dates (Figures 8 and 9).
- We originally proposed collecting water samples from three sites adjacent to stands of RCG and three sites without the immediate presence of RCG. However, due to environmental conditions along the river bank, and access issues, RCG was present at all of our sample sites.

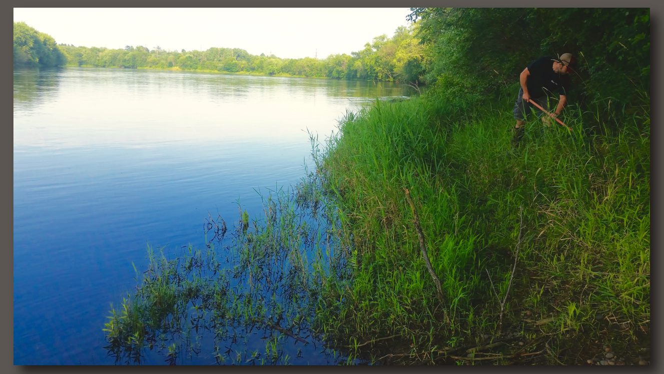

Figure 8. Site 1 at high discharge.

Figure 9. Site 1 at low discharge.

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