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Locate and mitigate the state of nitrate: Assessing potential sources of nutrients in tributaries to the Nooksack River

Alyssa Peter
Western Washington University

Melanie Roy
Western Washington University

Locate and mitigate the state of nitrate: Assessing potential sources of nutrients in tributaries to the Nooksack River

Alyssa Peter[1], Melanie Roy[2], and David Hooper[1]
[1]Dept. of Biology, WWU
[2]Dept. of Env.Sci, WWU

Introduction

- Since the early 1900s, nitrogen fertilizers and agricultural strategies have more than doubled the amount of people fed by a hectare of land (Compton et al., 2011). However, excess nitrogen inputs to the environment can result in groundwater contamination, eutrophication of freshwater and oceans, and air quality degradation.
- The Nooksack River basin in Whatcom County contains high levels of nutrient pollution. Nitrate concentrations have increased in some streams in Whatcom County compared to the 1990s (Cohan, 2018 *MS thesis*).
- We investigated the nutrient fluxes across several tributaries to the Nooksack River to understand the relative inputs of nutrients from Whatcom County and Canada through surface and groundwater.

Objectives

- We are aiming to understand the origin of excess nutrients in Whatcom County stream water through surface water and groundwater from either Canada or local land use.
- In this component of our overall study, we aim to determine
  - how nitrogen and phosphorous fluxes change longitudinally along these streams; and
  - how concentrations of nitrogen and phosphorous differ across creeks.
  - This information will help us understand the net effect of nutrient inputs and losses in the creeks as well as the impacts of groundwater contamination and other nutrient sources on tributaries to the Nooksack River.

Hypotheses

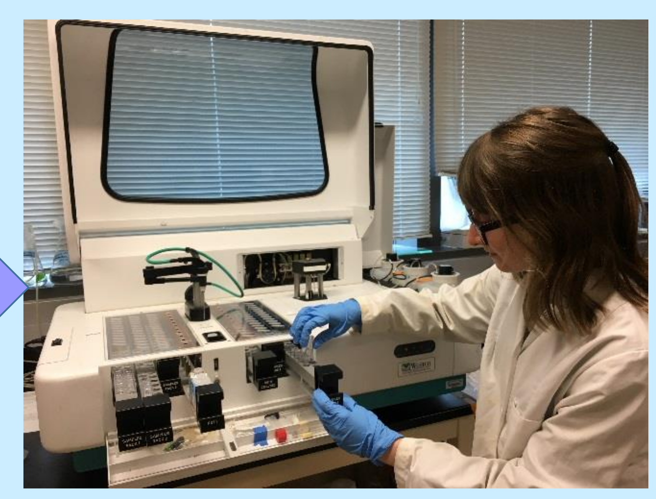
- We hypothesized 1) that fluxes of nitrogen (N) and phosphorus (P) would increase from upstream to downstream sampling sites, anticipating that inputs of nutrients exceed nutrient outputs, such as algal uptake and denitrification.
- 2) that concentrations of nitrate would be greater in the streams located in the northern half of the Sumas-Blaine aquifer, where higher levels of groundwater contamination by nitrate have been observed (DOE, 2012).

In the field

Collect water samples from each creek.

Measure stream width, depth, and velocity to calculate total stream discharge.

In the lab



Analyze samples for concentrations of nitrate, and phosphate.

Figure 1. We collected water samples from each creek and measured stream width, depth, and velocity to calculate total stream discharge). In lab, we analyzed the samples for concentrations of nutrients using a SmartChem autoanalyzer.

Methods

- We sampled multiple points along the lengths of six creeks (Figure 1). Three of these, Kamm, Fishtrap, and Bertrand are closest to the Canadian border and fed by the central portion of the Sumas-Blaine aquifer. Tenmile and Deer creeks are located at the Southern end of the aquifer, and Schell Creek is not fed by the aquifer (Figure 2).
- Then, with the following equation, we calculated nutrient flux:
- nutrient flux (kg/day) = total stream discharge (m^3/day) x nutrient concentration (kg/L) x 1 L/1000m^3 =
- We paired our stream water samples with groundwater nitrate concentrations obtained by the Department of Ecology between 1981 and 2008 (DOE 2012).

Results and Discussion

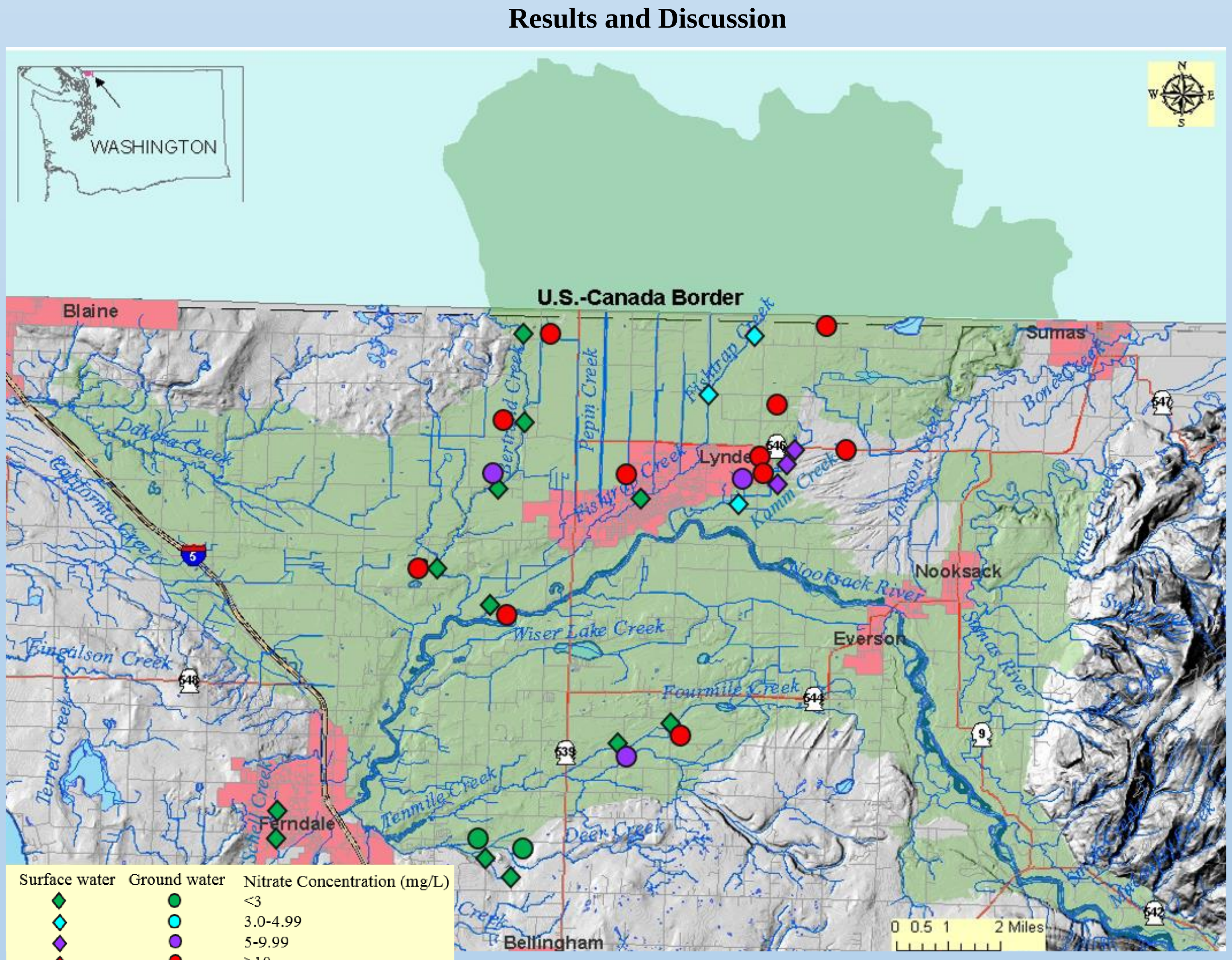


Figure 2. Map of sampled creeks (Kamm, Fishtrap, Bertrand, Tenmile, Deer, Schell) and the underlying Sumas-Blaine Aquifer, outlined in green. Diamonds indicate surface water sampling locations and circles represent the groundwater wells sampled between 1981 and 2008 (DOE, 2012). Colors indicate concentrations of nitrate in mg/L in our stream samples and maximum concentrations in the groundwater samples.

Main points for figure 2:

1. Creeks situated in the northern half of the Sumas-Blaine aquifer (Bertrand, Fishtrap, Kamm) had higher concentrations of nitrate in stream water. The similarly elevated nitrate concentrations in that area's groundwater may contribute to nitrate contamination of the surface water.
   a. Deer Creek is located at the southern edge of the aquifer and Schell Creek is not fed by the aquifer. These creeks had the lowest nitrate concentrations, perhaps because the aquifer contributes little to no nitrate-contaminated groundwater.
2. We will be analyzing groundwater and stream water (Bertrand and Fishtrap creeks) from just north of the Canadian border to understand potential inputs from there.
3. Differences in groundwater inputs and surrounding land use practices, including crop and lawn fertilization, manure inputs, and stormwater runoff, could affect the nutrient concentration patterns across creeks (Claussen and Lenz 1999) (Messiga et al. 2017).

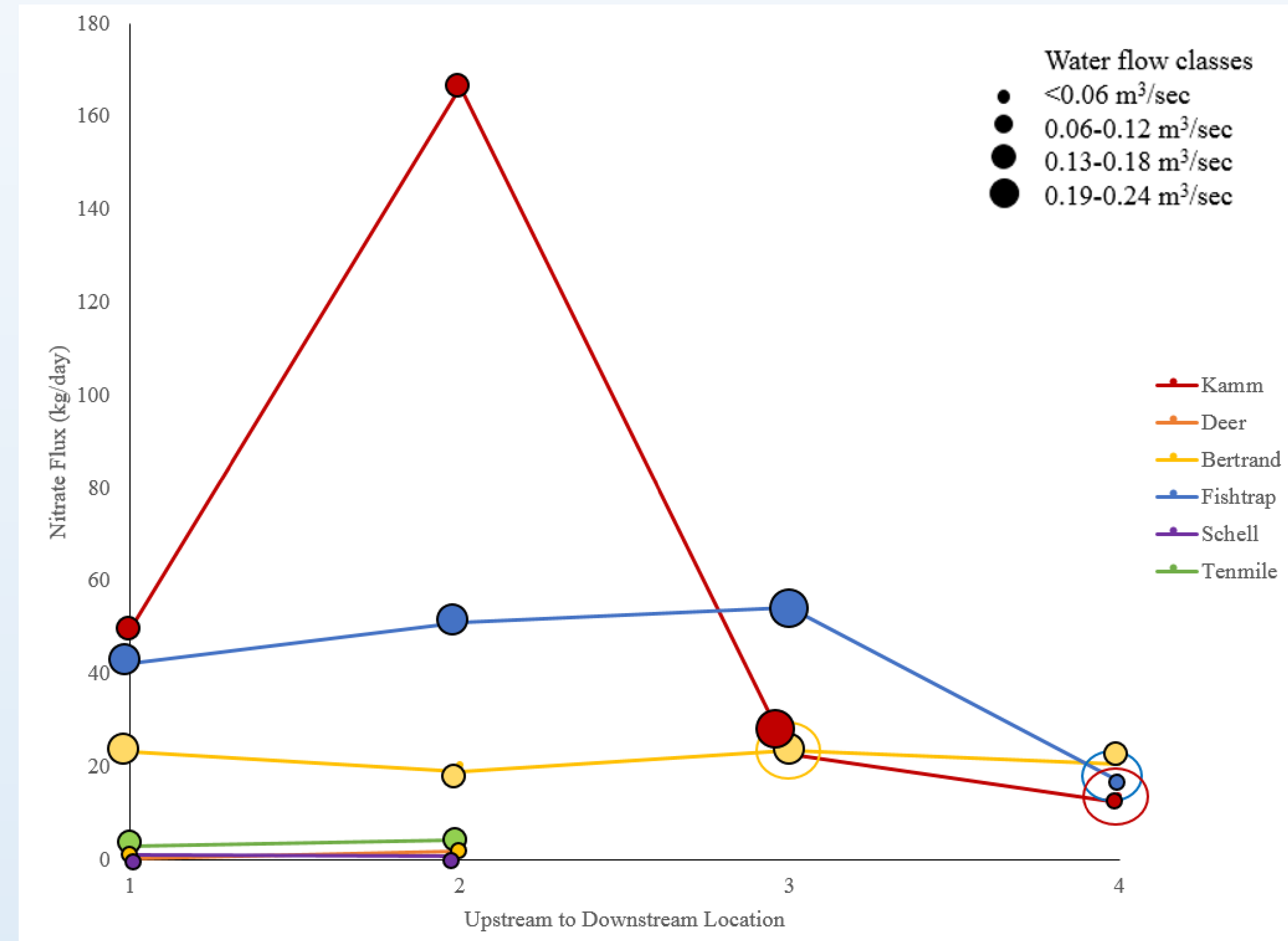


Figure 3. Nitrate fluxes in kg/day of six creeks at upstream and downstream locations. Bertrand, Fishtrap, and Kamm were each sampled at four locations, while Deer, Schell, and Tenmile were each sampled at two locations. Locations are ranked 1 to 4, 1 as the most upstream location and 4 as the most downstream location. Open circles mark stream sites that were incompletely measured for water flow, so values represent a minimum nutrient flux. Size of points indicates water flow class (m^3/sec).

Main points for figure 3:

1. All creeks lacked a consistent increase or decrease in fluxes from upstream to downstream. This suggests that the net impact of sources and losses of nitrate is variable at each sampling location.
2. Of all streams sampled, Kamm Creek had the highest nitrate flux at its second most upstream site, from 4 to 8 times fluxes in the other northern creeks.
   a. From the most upstream to the second most upstream site, the streamflow increased threefold, but the concentration was only 1.1 times greater, suggesting large ground water and surface water inputs.
   b. The dramatic decrease in nitrate flux from points 2 to 3 indicates that outputs of nitrate are exceeding inputs between these two points.
3. The nitrate fluxes in Fishtrap Creek remained mostly constant at the three most upstream sites, but decreased by a factor of three at the most downstream site. Outputs of nitrate, including algal uptake and denitrification, may be exceeding inputs of nitrate from groundwater and surface runoff. The water flow measurements at this point also represent a minimum flow, possibly underestimating the flux value.
4. Bertrand Creek's nitrate fluxes were similar at all sampling locations, this indicates that inputs and outputs of nitrate are relatively equal and constant along the stream.
5. The nitrate fluxes of Tenmile, Deer, and Schell creeks were between 3 to 550 times lower than the fluxes of Bertrand, Kamm, and Fishtrap creeks, reflecting both lower nitrate concentrations and lower streamflow (particularly for Schell Creek).

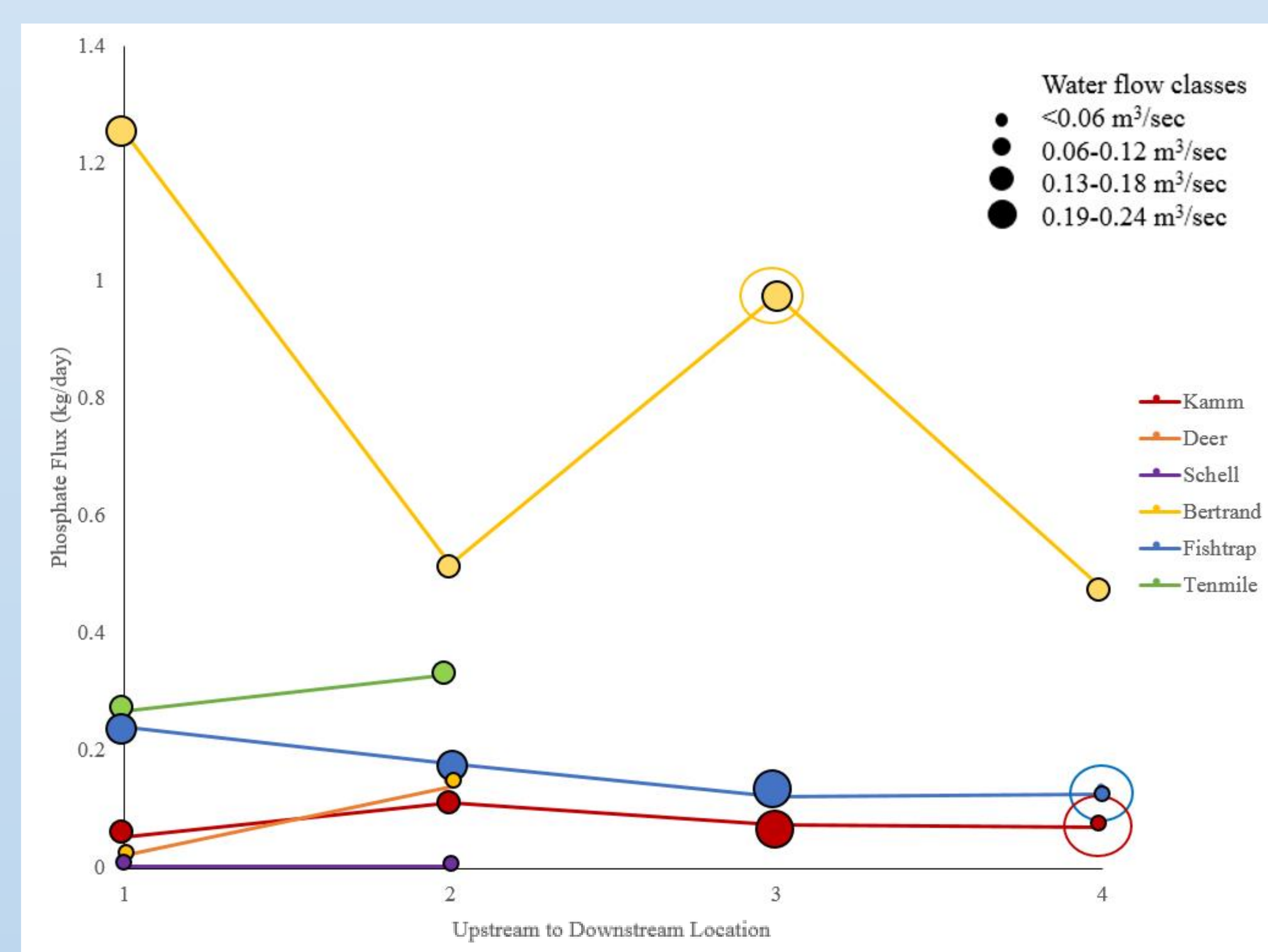


Figure 4. Phosphate flux in kg/day for six creeks at upstream and downstream locations. Symbols as in Fig. 3.

Main points for figure 4:

1. Phosphate makes up most the total phosphorous in these streams, so organic phosphorous is a smaller contributor to overall phosphorous fluxes (total phosphorous data not shown).
2. In Bertrand Creek, phosphate fluxes increased by a factor of two between the second and third most upstream sites, while the streamflow values at these locations are similar. Inputs of phosphate, including phosphate fertilizer, animal waste, or human waste are therefore exceeding outputs, such as uptake by organisms.
3. The phosphate fluxes of Kamm and Fishtrap creeks do not vary across their respective upstream and downstream sampling sites, indicating inputs and outputs are similar in magnitude for both streams.
4. Deer and Tenmile have strong increases in phosphate flux resulting from increases in streamflow, not increases in nutrient concentrations.
5. Low fluxes at Schell reflect its small stream size and water flow compared to the other creeks. Concentrations of phosphate increased by a factor of 2 at the downstream sampling site, but the water flow decreased by a factor of 1.3.

Conclusions

1. Surface and groundwater nitrate concentrations are higher in northern Whatcom County, but further analyses are required to differentiate among potential sources.
2. Streams varied in longitudinal patterns of N and P flux.
   a. Where fluxes decreased, biological processing (algal uptake or denitrification) exceeded new inputs. Differentiating between these loss pathways has implications for eutrophication.

3. Increases in flux indicate inputs of from surrounding land use or groundwater that warrant further understanding to mitigate potential negative effects on water quality.

Future Applications

- Additional data will help us determine the identity and contribution of nutrient pollution sources:
  - Nitrate concentrations in groundwater samples paired to our stream samples are currently being processed by the Department of Ecology. Nitrogen and oxygen isotope ratios in both groundwater and stream water samples are also currently being processed by Gordon Holtgrieve at the University of Washington. Bertrand and Fishtrap stream water samples collected north of the US-Canada border by Environment and Climate Change Canada will be assessed for nutrient concentrations and fluxes.

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