

Insights into the spatial and temporal variability of water isotopic signatures in a small agricultural watershed in Atlantic Canada

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Site location





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Black Brook Watershed (BBW)

- 14.5 km²
- Hilly landscape
- 65% agricultural land

Climate

- Moderately cool boreal
- 1100 mm yr⁻¹ precipitation
 (30% snow)
- 3.5 °C average air temperature
- Significant snowmelt event in mid-spring







Hydrogeological settings

- Glacial drift (~ 2m) over fractured bedrock (shale)
- Very low matrix porosity



Rapid transport through fractures





Monitoring program

- Sampling between 2011 and 2014
- 60 wells, 3 precipitation and 3 stream locations
- Water isotopes, including major ions and nitrate isotopes
 - Mix of seasonal and monthly sampling





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Groundwater wells

- Domestic wells
 - Cased to bedrock
 - Depth of casing/well unknown in some cases

	Depth	Casing	Sampling
Well Type	(mbg)	L (m)	int. L (m)
Domestic wells	54.6	12.0	47.3
Piezometers	39.8	6.0	5.5
Municipal wells	53.3	8.9	44.4
Average	49.9	10.8	46.6



Piezometers



- PVC risers and slotted
 - screens
- Some with multiple ports
- Municipal wells



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Sampling - seasonal distribution





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Local Meteoric Water Line (LMWL)

- 63 cumulative (monthly) and 30 seasonal samples
- 3 precipitation gauges





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Isotopic signature and temperature







Seasonal dynamics

- Groundwater
 showing
 evidence of
 recharge
- Streams slightly enriched due to precipitation / surface runoff





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Stable isotope composition (entire data set)



Precipitation shows the largest spread

- No significant deviations from the LMWL
- Groundwater the dominant source of streamflow



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Isotopic signature vs. well type

- No significant difference when considering
 - Well types
 - Position within the watershed
 - Position inside/ outside of the watershed







Isotopic signature vs well depth

Isotopically depleted 0 water in 10 Mid-point depth (mbg) 20 deep wells 30 < 10 m 40 10-20 m 50 ▲ 20-30 m 60 30-50 70 > 50 m 80 90 100 -100 -80 -60 -20 -40 0 δ²H (‰)





Isotopic signature vs. sampling interval

- Shallow aquifer
 slightly
 enriched
- Isotopic
 signature not
 sensitive to the
 depth of the
 bottom of the
 sampling
 interval







Conclusions

- Precipitation
 - Similar signatures with other areas in Canada
 - No spatial variation at watershed scale
 - Significant seasonal and short-term (i.e. event) variation
- Groundwater
 - Derived from local modern precipitation; muted seasonal variations
 - Aquifer waters are well mixed
 - Rapid infiltration/ percolation prevents evaporative losses
 - Main source for streamflow on both annual (~80%) and event (min. ~50%) basis
 - Spring snowmelt is the most significant contributor to recharge
 - Slightly depleted water in the deepest wells





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