Waterloo Field School 2019

The third generation of doctoral candidates in the Integrated Hydrosystem Modelling RTG attended the Hydrogeology Field School at the **University of Waterloo** (Canada) from April 21st to May 10th 2019. The course was run by Dr. Colby Steelman with the help of his teaching assistants Joey Ju and Max Salman. It was a blend of lectures, field work and demonstrations, as well as individual and group assignments. Teaching was performed by professors, researchers, industry experts and graduate or post-graduate students. Our fellow attendees were graduate students from different Canadian universities (Waterloo, Guelph, McMaster, Queen's and others).



The course started with an overview of the basics of hydrology and **water level measurements** in the field. We were given a glimpse into the subsurface architecture with a lecture by Dr. Martin Ross on the local Quaternary geology. A safety briefing was conducted by Dr. Brewster Conant, making us aware of the risks associated with drilling operations and field work. He emphasized the need to plan field work and be prepared for emergencies by using risk assessment tools to identify potential risks and plan mitigation measures.

Our field site was located at the North Campus of the University – a grassy swale between parking lots, dotted with wells from previous field schools. Our first task was to **install piezometers** in teams of three or four; a first time experience for some of us. A hand auger was used to access the shallow water table. Piezometers were installed at different levels in the borehole, before water level and electrical conductivity measurements were taken.

As our first introduction to characterizing the aquifer, we were lectured on how slug tests can be used to give an idea of near well bore properties by estimating hydraulic conductivity. We peformed constant, falling and rising head **slug tests** by manually recording time and water depth using a tape measure. We soon realized how uncertain this technique is, due to high human error. We also had the opportunity to use a transducer that automatically recorded measurements, which was much appreciated. The range in hydraulic conductivity estimated using Hvorslev's method at the different well locations was an eye-opener in terms of the heterogeneity of the aquifer within our small study area.

We observed **drilling and coring** operations using a split spoon sampling and augering and logged the core to identify lithology, textures and depositional features. This enabled us to identify the most suitable aquifer sections to complete the well. Using the water-level measurements collected at different wells in the field area, we created a water-table map and a flow-net. This also had to tie in the observations from borehole logs to the flow-net.

A highlight of the field course certainly was the 24 hour **pumping test** conducted under the supervision of Prof. Dave Rudolph. It comprised day and night water level measurements in many observation wells throughout the pumping and recovery phase. Furthermore, some of the wells were sampled and tested for Cl^-, NO_3^-, alkalinity and dissolved O_2, which further resolved the picture of the subsurface. Mapping the chloride concentrations in the area pointed to a known problem of salt contamination in the groundwater due to application of road salt in the parking lot.



Another noteworthy event was our trip to the **University of Guelph** where we learned about geophysical logging and testing techniques in fractured rocks. We also had demonstrations in Waterloo involving geophysical techniques like resistivity and electromagnetic methods, as well as organic sampling. We learned about techniques like the application of isotope geochemistry and infrared sensors. A lecture of environmental site characterization provided examples on how to piece together all the information to form a hypothesis or even develop conceptual models about site contamination.

Our final field task was the installation of seepage meters in Lake Marie to measure **surface-water groundwater interactions**. Guided by Dave Lee, we made our own piezometers which were used in conjunction with handmade seepage meters. Geared up in our hip-waders and equipped with simple half drums and plastic bags, we measured groundwater discharge into the (cold) lake. Stream discharge was also measured, using three different methods: a tracer test, a v-shaped weir and a bucket.

During the field course, we learned how data we frequently use are actually obtained. It is important for modelers to understand data quality, measurement uncertainty, and tool limitations. Integrating different types of data may help overcome an anchoring bias. All available data should be inspected to get the most comprehensive overview possible. This may then help in making reasonable **modeling decisions**. Since models are simplified representations of environmental complexity, uncertainty quantification can be a helpful tool to draw justified conclusions and avoid overconfidence. In conclusion, good cooperation between the field team and the modeler is crucial for fruitful and efficient investigations.