Aquifer Characterization in NEBC - Overview and 2015-16 Sampling Plan

The goal of aquifer characterization in North Eastern British Columbia (NEBC) is to enhance water security in the region and help inform the sustainable use and management of groundwater. Very little information has historically been available regarding groundwater in Northern BC. Regional Districts in cooperation with various iterations of Environment Canada and Agriculture Canada have conducted local studies to identify water sources in rural areas. The province of BC has created aquifer maps based on limited water well information. In 2011, a team of academics and provincial groundwater professionals began collaborating with a goal to characterize aquifers in NEBC. This effort has revealed how sparse or non-existent information about quaternary/bedrock aquifers and their geology truly is and has shaped the ongoing effort to create regional and specific knowledge about groundwater.

Given the limited data available, the NE aquifer characterization project started in 2011 with four key objectives:

1. Expansion of the observation well network
2. Water well chemistry survey to identify different aquifers (i.e., chemical signatures)
3. Geophysical survey of aquifers in a pilot study area (Groundbirch)
4. Development of aquifer models and information summaries for the Peace Region.

The project has evolved over the past 5 years and has made great progress toward achieving those objectives.

1. Observation Wells:

6 new observation wells have been established across the Groundbirch/Dawson Creek Area. 4 are online and transmit near-real time data to the internet for public access. One of the wells was artesian and is currently monitored manually. The 6th well awaits monitoring equipment.

2. Water Well Chemistry Survey

The water well chemistry survey quickly evolved into the water well and spring chemistry survey. Since 2011, 189 sites have been sampled across the Peace Region (Figure 1 Below). The suite of parameters sampled for has been enhanced since 2011. The main enhancement has been the addition of dissolved gases and the analyses of C14 isotopes. In addition to samples, a conversation is also held with the landowner where we learn about the history of the well, what the water is used for, any concerns or problems with quantity or quality, construction issues and information about the well log.

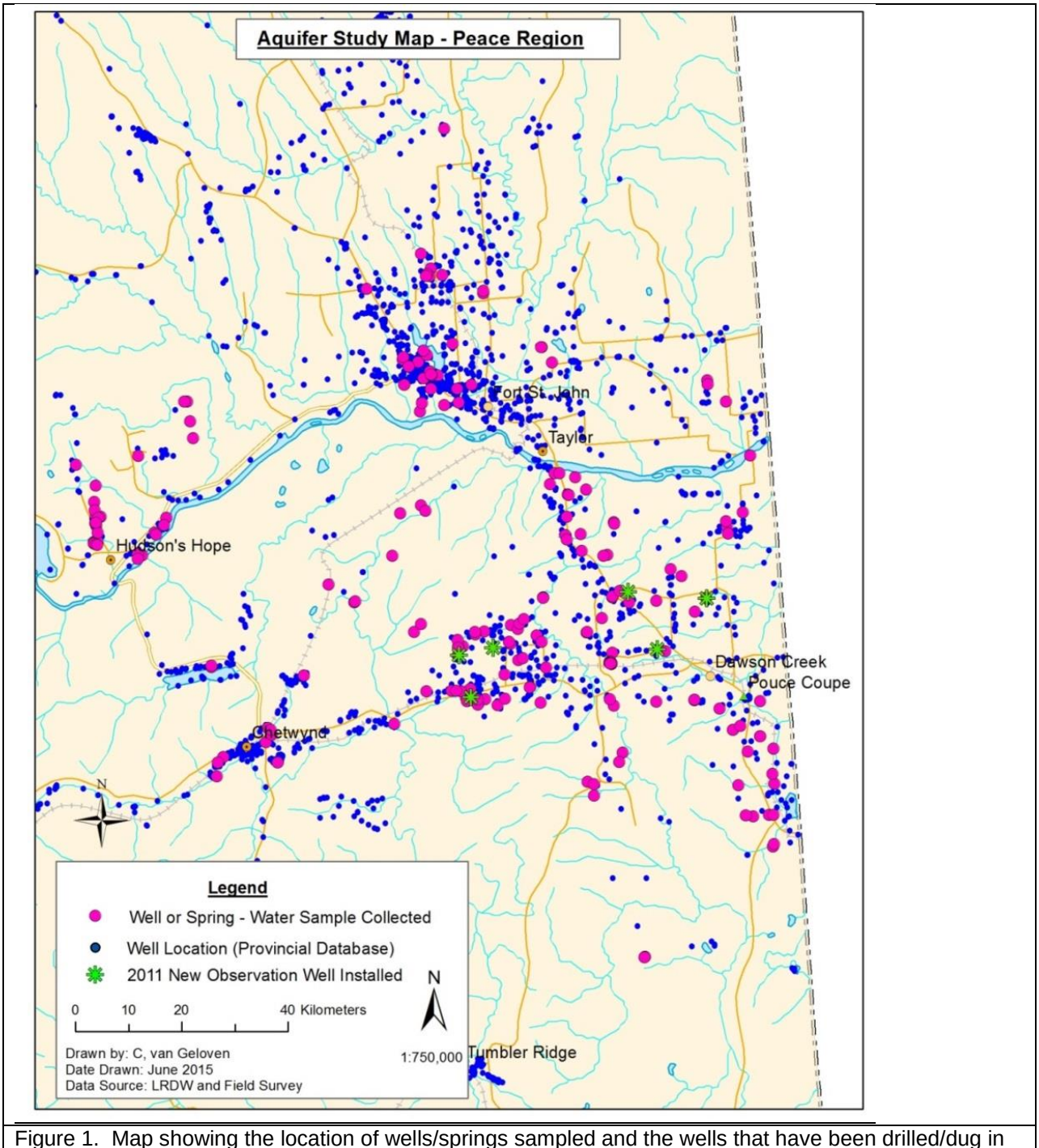

Figure 1. Map showing the location of wells/springs sampled and the wells that have been drilled/dug in the Peace.

Chemistry

Simon Fraser University (SFU) and professors Dr. Dirk Kirste and Dr. Diana Allen have been the lead advisors on the groundwater chemistry survey and are providing interpretation of the data. A primary focus of their effort is to explain the geology of the area in terms of groundwater composition and the evolution of groundwater chemistry as it interacts with the quaternary and bedrock aquifers. As a comprehensive database of groundwater chemistry is built, further analyses of the samples are being completed to interpret various isotopes and attempt to narrow down the estimate of residence time in various aquifers (i.e., how long has it been since the water sample fell from the atmosphere as rain or snow onto the earth's surface). Collectively, this information helps us to refine the boundaries of various aquifers and start to understand recharge dynamics which ultimately informs the sustainable use of groundwater in the region.

Additionally, SFU graduate students and post-doc professionals are working on three specific projects in the region which build upon the foundational work being carried out by the province and Dr. Kirste and Dr. Allen. These projects include:

a. Aquifer vulnerability mapping across the Peace Region,
b. A focussed study to enhance understanding of groundwater spring dynamics across the region (catchment, recharge, sensitivity, role in the overall hydrogeology of the region)
c. Risk Assessment (Risk compared to Resilience) with a focus on shale gas development in the context of quaternary and bedrock aquifers being used as a source of freshwater for various purposes.

Sample Year	Routine parameters analyzed (all sites)	Parameters analyzed at select sites
2011-2012	Metals (Al, As, Ba, Br, B, Ca, Fe, Li, Mg, Mo, Mn, K, Na, Sr, Zn) Cations/Anions (HCO3, Cl, F, SO4, NH4, NO3, PO4, SiO2) Field Parameters (conductivity, pH, Dissolved oxygen, temperature, Oxidation/Reduction Potential) Oxygen isotopes	Tritium isotopes
2012-2013		
2013-14	Additional to previous years (Dissolved methane and isotopes)	
2014-15	Additional to Previous years (C14 isotopes)	
2015-16 (proposed)	Additional to Previous Years (TSS, TOC, DOC, Turbidity, E. coli bacteria, Total Coliforms) Additional Dissolved Gasses (C1-C4, Ar, N2, O2, CO2, H2 and isotopes)	Microscopic Partical Analyses, C14 isotopes

Additional Information Collected at Well or Spring
Well owner contact info (phone, email, postal address, permission to revisit in future)
What the water is being used for?
GPS position of well head (x, y and z) – data post-processed for <30cm accuracy
Construction information (Drilled, dug, spring, pit well, etc.)
Depth to water from well head (Measured with Sounder)
Well info if available (well tag, total depth, pump depth, well log, original yield, depth to screen)
Historical issues with water quantity (sanding in/sedimentation, loss of supply/level, productivity, etc.)
Historical issues with water quality (gas, colour, scale, turbidity, dissolved metals, etc.)
Any actions taken to resolve issues (construction, repairs, treatment, etc.)

Dissolved Gas

Building a Database of dissolved gasses in quaternary and bedrock aquifers is a valuable enhancement to aquifer characterization in the region. Within this project, sampling for dissolved gases began in 2013-14, and the analyses was completed by a laboratory under contract. In 2015, the opportunity to begin collaborating with the University of Victoria (UVIC) and Dr. Michael Whiticar became available. In addition to gaining the experience and knowledge of Dr. Whiticar, we will also be able to analyze very low concentrations of dissolved gas and the results of the NE aquifer characterization study will be able to contribute to a Natural Gas Atlas for Northern British Columbia which Dr. Whiticar is leading.

The Natural Gas Atlas is a database of natural gas isotopes analyzed from the range of formations being explored and/or developed for industrial purpose in Northern British Columbia. The analyses of dissolved gas isotopes collected from quaternary and bedrock aquifers across the Montnay can then be placed into context when referenced to the gases found in the underlying formation. This becomes the foundation for understanding if any unchecked connections exist between deeper gas bearing formations and surficial aquifers.

3. Palleovalley Mapping and Geophysical survey of aquifers in the Groundbircha pilot study area
(Lead by the Ministry of Energy and Mines and Dr. Adrian Hickin)

The approach used was to test electromagnetic (EM) and shallow seismic geophysical methods accompanied by drilling as a way to establish the geological framework for the aquifers that lie up to 300m below the surface.

The rural area of Groundbirch was selected for a pilot study to map palleovalleys (i.e. valleys that existed prior to the last ice age and are now filled with sediments deposited during and after that last ice age) and aquifers for a number of reasons which include: numerous water wells at various depths, grid pattern roads, gentle terrain with pronounced surficial landforms, open fields (for access) and a nearby exposed palleovalley along the cutbanks of Coldstream Creek.

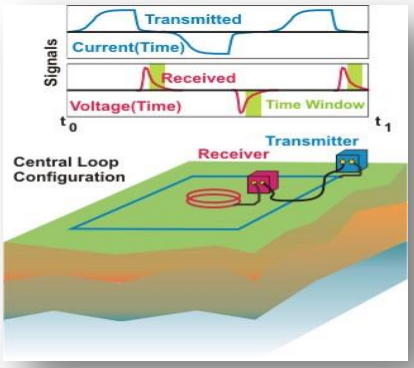

Fig.2: diagram of resistivity survey methodology.

Fig. 3: photo of resistivity survey in progress

The methods used included:

- Paleovalley mapping using water well information (i.e., deeper productive wells in contrast with shallower less productive wells).
- Ground based EM survey
- Shallow Vibraseis Seismic Survey (Geological Survey of Canada Partner)
- Confirmation Drilling (drilling at strategic locations and recovering/logging the core to confirm EM and Seismic interpretations).
- Iterative Modelling (continually adjusting the EM and seismic survey interpretation based on information provided by the confirmation drilling, using the new iterations to help plan the next drilling location and make the final interpretations)

Fig. 4: Photo of drilling and analyses of drill core to confirm the finding of the resistivity survey.

Fig 5: 3D image showing results of the resistivity survey placed on google earth background.

The Pilot study was able to successfully create an image of the various particle sizes and quaternary aquifers in the study area. Figure 5 (above) above offers a 3D interpretation of the lithology that can be expected up to 300m below the surface. Building on the success of this pilot study, Geoscience BC is funding an aerial EM survey of the North Peace area that is taking place in the summer of 2015.

2015/16 Sampling Plan

The water chemistry and dissolved gas sampling and analyses plan proposed for the summer of 2015 is a combination of a target 50 new sample sites and revisiting 120 existing sites.

The general focus for new sample sites is the upper halfway-Pink Mountain-Prespatou-Doig River area however we welcome new water well and spring samples from anywhere in the Peace Region.

Criteria for re-visits are simply to gain fairly even coverage of the sample region to gain a good representation of dissolved gases in water.

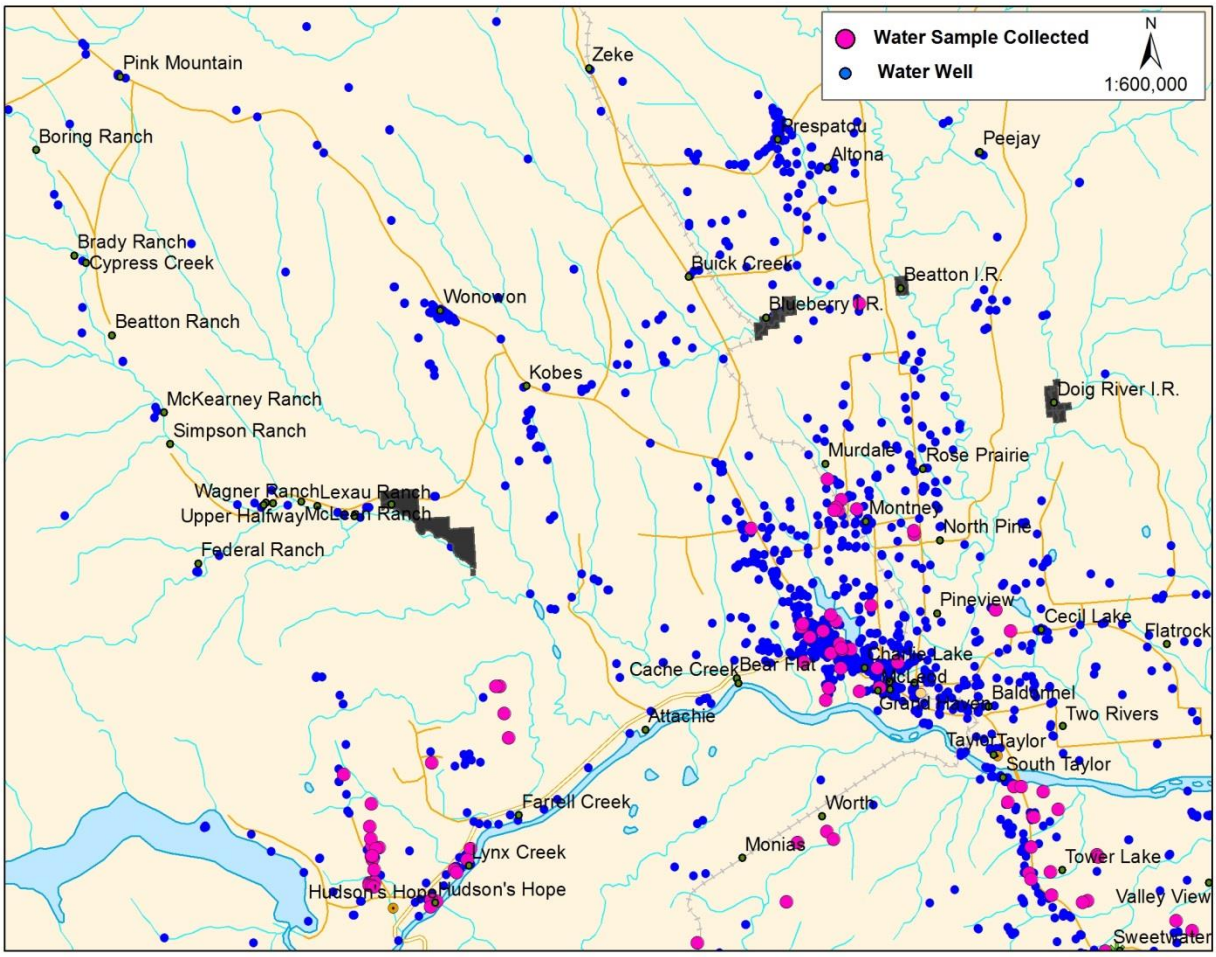

Figure 6. Map showing the areas in the North Peace where more water well and spring samples are desired.