BC-OGRIS 2015-2016 Final Report for the Peace Project

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Contents

Background

The province of British Columbia has introduced a new regulatory framework for groundwater this year with the Water Sustainability Act. The modernization of water use in British Columbia is long overdue and is being driven, in part, by the current and upcoming demands on the Province's groundwater resources from shale gas development and the Province's LNG strategy. Part of the modernization will see the licensing of groundwater extraction and use in the province. A primary component of this new framework will be the Northeast Water Strategy; a process to ensure the sustainable use of water so as to maintain healthy aquatic ecosystems. A key part of the Northeast Water Strategy is the Northeast Water Monitoring System - a proposed network of observation points which will provide baseline information on water quality and use from subsurface aquifers.

The ability to properly monitor groundwater requires a solid understanding of the distribution, thickness and quality of water aquifers. Unfortunately, the regional knowledge of aquifers in northeast BC is very poor, as shown below in Figure 1.

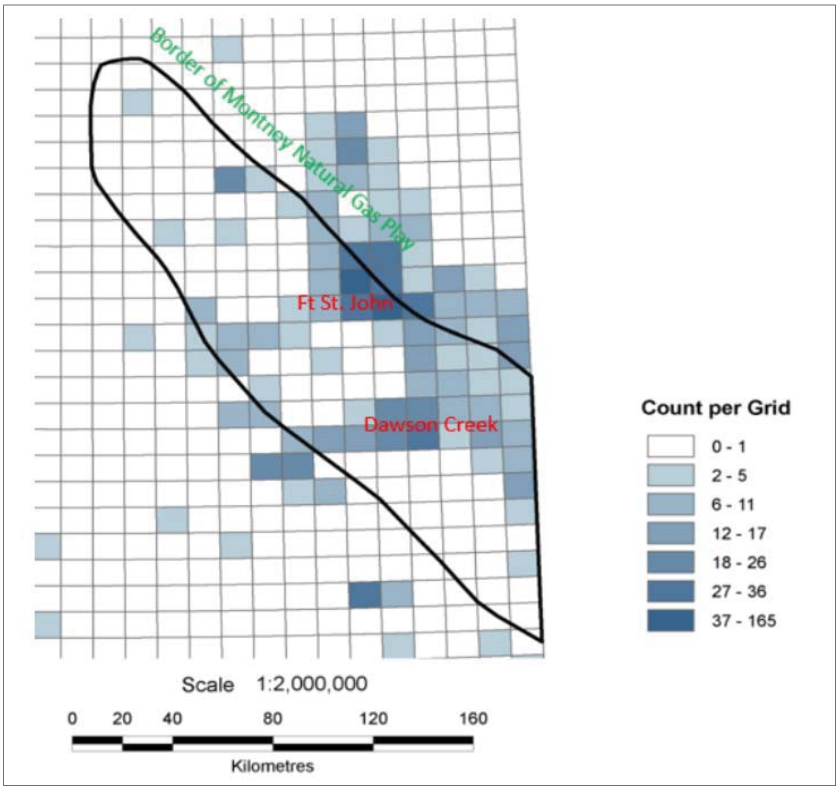

Figure 1. *Map of the greater Montney Natural Gas Play showing abundance of groundwater/aquifer data points per grid cell (e.g. shallow domestic water wells, ground water monitoring wells, pump tests etc.). Grid cells 10km x10km. The deeper the blue hue, the more groundwater data points that exists. Areas of the white squares may lack groundwater/aquifer data (source: Geoscience BC Montney Water Project* (http://www.geosciencebc.com/i/project_data/GBC_Report2011-7/GBC_Report2011-07_BCMEM%20OF2011-1.pdf)

The ability of the Ministry of Environment to adequately map aquifers is generally restricted to areas where a robust data set exists due to a large number of water wells that have been drilled and reported. In NEBC, this is restricted to portions of the south Peace area where aquifers have been utilized through agricultural activity. Although aquifers can be delineated through drilling, this is time consuming and cost prohibitive from a regional mapping perspective. A more cost effective approach is to carry out a remote sensing survey, supported by existing surface and subsurface data, to delineate groundwater aquifers.

In support of the new Water Sustainability Act and of the anticipated LNG industry, this project will undertake to map aquifers, initially within the Montney gas play, through a multidisciplinary project which will include airborne geophysical mapping of shallow aquifers along with the integration of shallow 3D seismic data and shallow well data. Potential aquifers delineated by the airborne electromagnetic (EM) surveys will be verified through the drilling of shallow wells and comparison to 3D seismic data, previous aquifer characterization and mapping work, and available well data. Pumping tests will be conducted at the newly drilled wells to assess aquifer hydrogeologic properties. Groundwater quality will be assessed at the new wells and reviewed with existing datasets to characterize aquifer groundwater quality. Where appropriate, some of the wells drilled to ground truth the EM shallow aquifer mapping, will be converted into Provincial regional “monitoring” or “observation” wells.

The project will deliver geophysical maps (e.g. resistivity, resistivity depth-slices), aquifer information including delineated areas of newly identified aquifers, updates to previously mapped aquifer extents, and aquifer characterization information (e.g., aquifer material/lithology, thickness, hydrogeologic properties), interpreted Quaternary depth maps, reports for new groundwater monitoring wells (including well logs and pumping test results), and a GIS-based decision support tool to allow open access to data gathered from the project.

It is expected that this project will deliver the following value proposition:

- Facilitate First Nations with planning with respect to groundwater
- Provide a basis to assess aquifer productivity (and quality) potential and allow sourcing new or alternate water or source security for communities, agricultural and natural gas sectors
- Provide industry and government with the technical information needed to optimally place observation wells for the Northeast Water Monitoring System
- Enable continued responsible natural gas development
- Baseline resistivity maps which can be used for reference in case of groundwater contamination

- Provide industry and the resource sector with key information for spill mitigation planning, and completing preliminary hydrogeological assessment for environmental impact studies, or other site investigations.
- Aggregate mapping will help with optimal infrastructure development
- Will aid in infrastructure planning
- Enhanced planning and potential cost savings (and liability reduction) for drilling programs with respect to surface casing depth
- Provide regulator and Government with the data needed to make informed decisions on sustainable groundwater usage, protection
- A public-facing GIS-based decision support tool will be developed to house groundwater and aquifer information gathered from the project and other available groundwater/aquifer information.

Project Plan

Technical Plan

- Fly airborne electromagnetic (EM) geophysical program
- Data processing, and 3D EM inversion
- Gather geological and geophysical data from shallow wells in the region
- Normalize all wells which have gamma ray (GR)/neutron/resistivity logs over surface casing. These logs will be used to geophysically calibrate EM program results
- Reprocess shallow 3D seismic, where available, and integrate into EM modelling/interpretation
- Design and drill 3-5 groundwater monitoring wells to calibrate interpretation
- Iterate aquifer interpretation based on groundwater and logging and testing program
- Create final Interpreted Maps and Report
- Develop GIS-based decision support tool for acquired aquifer/groundwater data

Outreach Plan

- Develop an outreach plan to communicate the program to the Treaty 8 First Nations
- Communicate program to communities in the project region

Timeline

- Three year project (end 2018)

Summary of Activities

Planning

The Peace Project has direct funding support from Geoscience BC, ConocoPhillips, Progress Energy, BC Oil & Gas Research and Innovation Society (BCOGRIS), and the Northern Development Initiative Trust (NDIT). In-kind support is being provided by the Ministry of Forest, Lands, and Natural Resource Operations (FLNRO), Ministry of the Environment (MoE), BC Oil & Gas Commission (BCOGC) and the Ministry of Natural Gas Development (MNGD).

An interest-based project planning approach was taken for the selection of the final project area. The original project area was based on technical considerations by groundwater experts from the Ministry of Forest, Lands and Natural Resource Operations, Ministry of the Environment and the BC Oil & Gas Commission. Through a process of engagement with Treaty 8 First Nations, communities and the energy sector, *interest-based considerations* were considered before the final project area was delineated.

The final survey area (Figure 2) comprised an area close to 9000 km2. Additional areas which were added for specific-interests of the Blueberry River- (the northeast extension along the Sikanni Chief River Valley), Halfway River- (near the community center) , Doig River First Nations (near the community center), along with the City of Fort St. John (the Charlie Lake area).

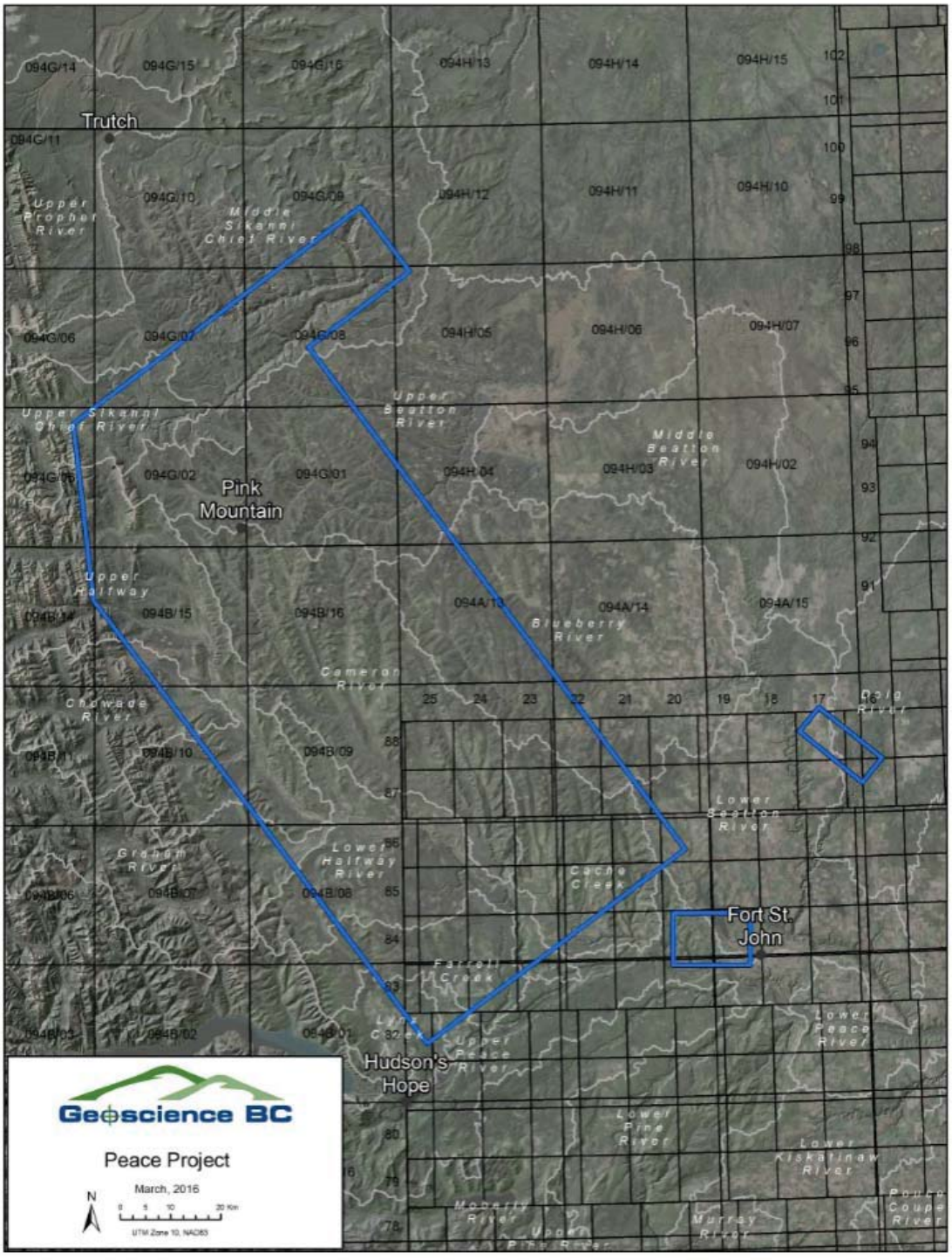

Figure 2. *Outline of Peace Project study area.* The small area around 84-19W6 is the Charlie Lake Block; the one around 88-17W6 is the Doig River Block.

Acquisition

The electromagnetic (EM) survey was designed with a flight line spacing of 600m and tie-lines at every 2400m. The total survey encompassed 20 999 line-km (~ 9 000km2).

The acquisition of the electromagnetic (EM) survey was undertaken by the Danish firm SkyTEM, and flown by Bailey Helicopters out of Fort St. John using a Eurocopter Astar B3 helicopter.

Figure 3. *SkyTEM system used to aerially map groundwater. The helicopter flies ~50m from the surface at ~120 km/h while recording all the necessary data in the underlying hoop.*

The survey was completed over the period from July 11th to August 22nd , 2015. The helicopter flew at an average flight speed of 118km/hr and the nominal flight height was ~50m. A total of three production days where lost due to inclement weather. The summer is a time when there are many Treaty 8 First Nation cultural events. As such, careful planning with the various Band Offices was needed in order avoid unnecessary disruptions due to the helicopter flight path. Staging areas were moved three times in order to accommodate Treaty 8 First Nation cultural activities. The communities where appreciative of the efforts to work around these important events.

Results and Discussion

EM Data processing

After the acquisition of the SkyTEM data, data processing was undertaken. Specifics on the processing runstream of the data is included in the *SkyTEM Survey: British Columbia, Canada Report* included in Appendix A. A resistivity depth plot generated from the EM data is shown as a demonstration of the type of information generated. Subsequent 1D and 2D modelling enabled a preliminary look at the survey and assessment of areas which may benefit from further 3D inversion work.

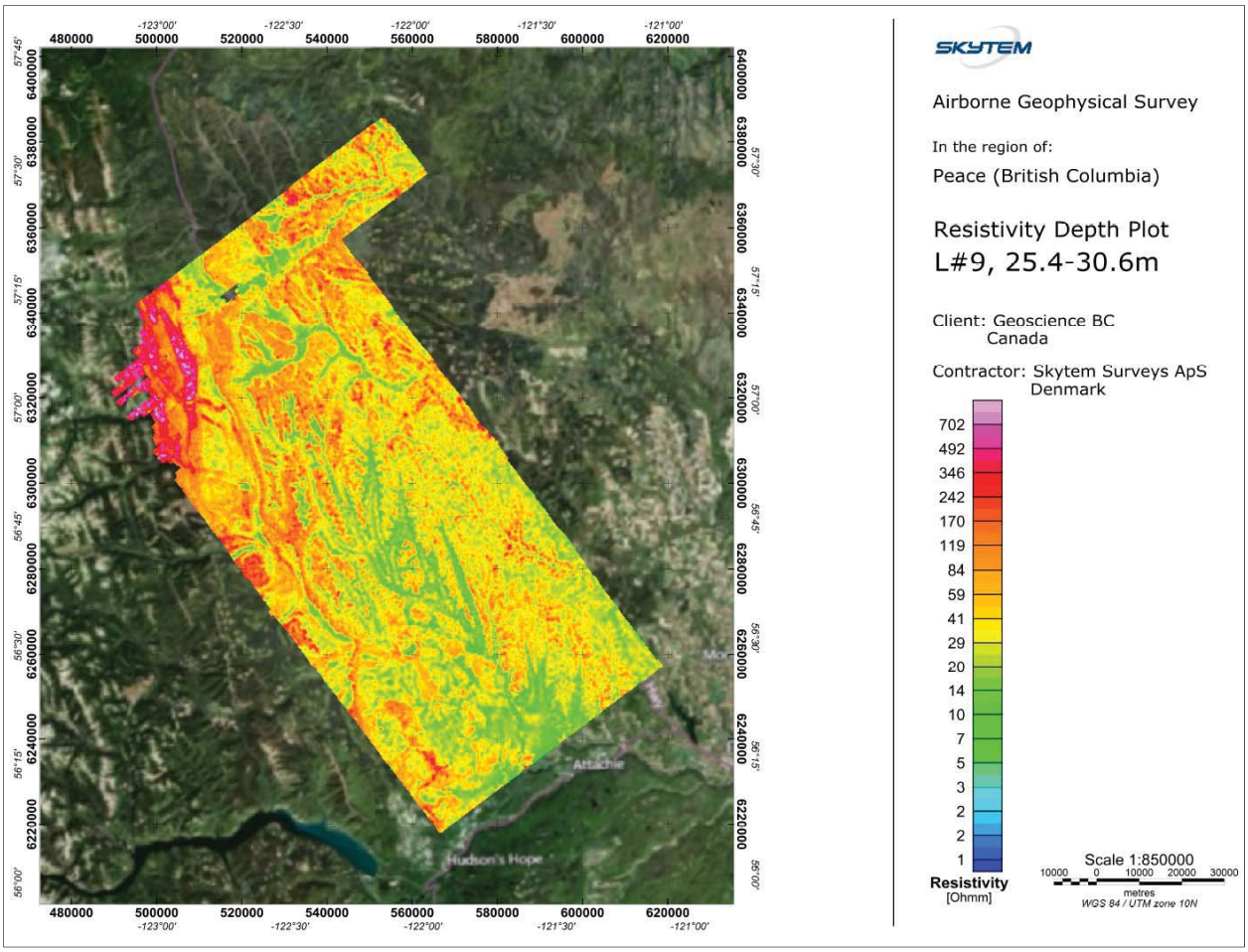

Figure 4. *Resistivity slice at a depth of 25.4-30.6m over the main survey block.*

The initial processing results are revealing that the survey has very good data quality (i.e. very good signal-to-noise ratio)

Shallow Section Geological Interpretation

In order to constrain the subsequent EM and hydrogeological interpretations, a study of the associated gamma-ray logs from the surface casing-portion (usually < 600m in depth) of approximately 1300 oil

and gas wells within the survey area, was commissioned with the intent of providing detailed geological information on the Quaternary and shallow bedrock section. The study was undertaken by Petrel Robertson Ltd. and Quaternary Geosciences Inc.

The initial part of the study involved re-calibrating the surface casing-attenuated gamma-ray logs using statistical techniques (see Appendix B, *Interpretation of Quaternary Sediments and depth to bedrock through data compilation and correction of gamma logs* for Quartero et al. methodology for gamma-ray correction). The resulting corrected gamma-ray logs provide a more accurate gamma-ray response, thereby ultimately enabling a better geological interpretation.

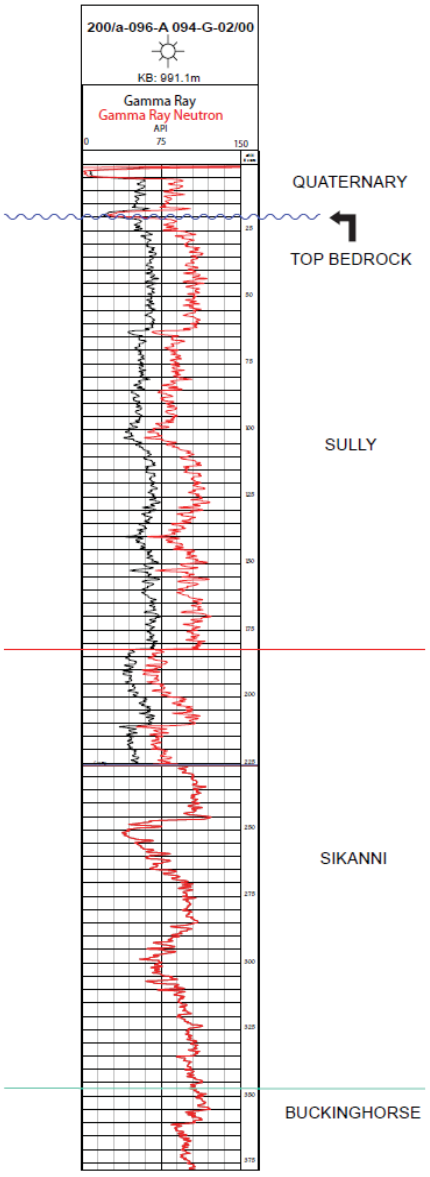

Figure 5. An example of a recalibrated gamma-ray log. The black line is the surface casing-attenuated log while the red line shows the casing-corrected line. The correction of the gamma ray log facilitates a more accurate interpretation of the shallow geological section. (2015, PRCL Interpretation of Quaternary Sediments and depth to bedrock through data compilation and correction of gamma logs)

Once all the gamma-ray logs had been re-calibrated, geological cross-sections were created in order to understand depth-to-bedrock and the shallow subsurface geology. Surface and Quaternary geology information was also integrated into the study, resulting in a dataset which can be used to geologically constrain the EM interpretation.

3D EM Inversion

Aarhus Geophysics, a Danish firm who pioneered airborne geophysical mapping of groundwater, is currently working on the detailed 3D EM inversion of four specific areas within the Peace Project. The 3D inversion of the EM data will produce a robust 3D model of the subsurface resistivity. The results of this study phase will provide the basis for subsequent hydrogeological modelling in the area.

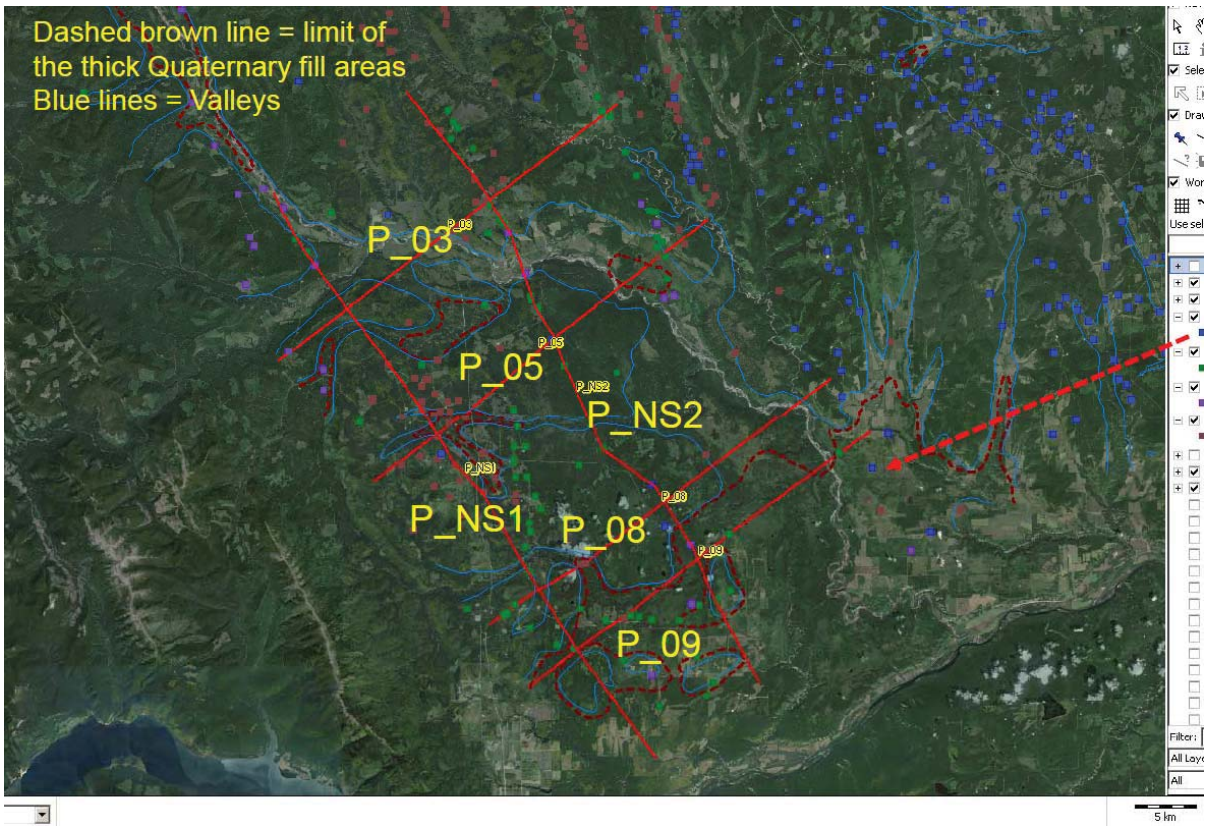

Figure 6. *The southwest corner of the main survey area showing surface geology features along with the subcropping geological formations (the blue, purple and green dots) which are used to constrain the 3D inversions. A small scale can be seen on the bottom right corner. (2016, Aarhus Geophysics. Results from Peace Project Geoscience BC- Phase 1).*

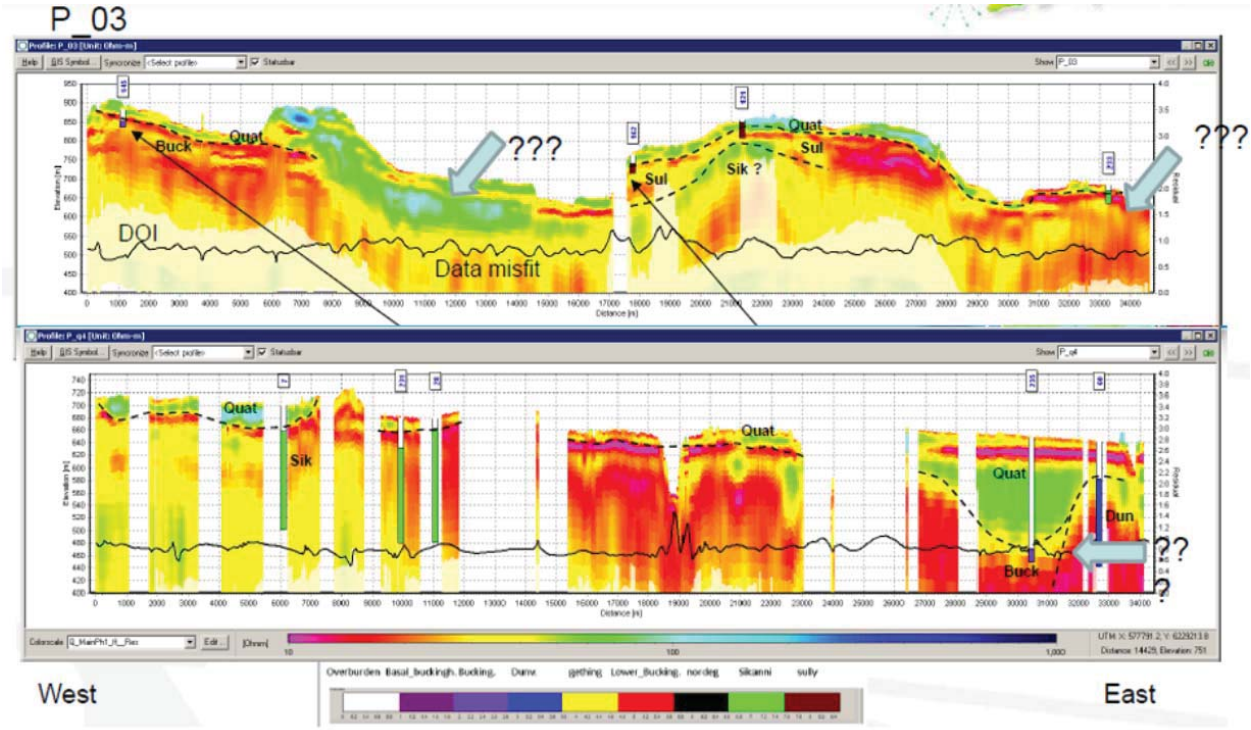

Figure 7. *Resistivity sections which have been constrained by the 3D inversions , showing the resultant geological interpretations. Note on the top cross-section, the arrow on the left side points to a prospective aquifer. The right-hand side of cross-section on the bottom shows a thick Quaternary (labelled "Quat") paleovalley*. Additional technical work will be needed to assess whether the thick paleovalley is a good aquifer.

Next Steps

- Finish 3D EM inversions
- Create geological and preliminary hydrogeological models
- Integrate 3D seismic (if data becomes available from energy companies)
- Drill and log 3-5 calibration wells
- Hydrogeological interpretation
- Develop GIS-based decision support tool for acquired aquifer/groundwater data

Communication Plan

Throughout the past year, Geoscience BC and its proponents have presented the following papers or presentations:

PRESENTATIONS

- Geoscience BC Oil & Gas Projects Update by Carlos Salas, VP Energy, Geoscience BC at *CSUR Technical Lunch, Calgary Alberta, November 12th, 2015*. http://www.geosciencebc.com/i/pdf/2015CSUR/1CarlosCSUR.pdf
- Contributions to Water Management in the Energy Sector by Brad Hayes, President, Petrel Robertson Consulting Ltd. at *CSUR Technical Lunch, Calgary Alberta, November 12th, 2015* and also at *Geoscience BC Day, Vancouver BC, October 8th, 2015.* http://www.geosciencebc.com/i/pdf/2015CSUR/3BradCSUR.pdf https://www.youtube.com/watch?v=OvXeG486LHE
- Using Airborne Geophysics to Map Groundwater by Bill Brown, SkyTEM Surveys ApsS at *Geoscience BC Day, Vancouver BC, October 8th, 2015* https://www.youtube.com/watch?v=NgPJQsAhA9Q
-

TECHNICAL PAPERS

- Brown, B., Gisselø, P. and Best, M. (2016): SkyTEM airborne electromagnetic systems for hydrogeological mapping in northeastern British Columbia; in Geoscience BC Summary of Activities 2015, Geoscience BC, Report 2016-1, p. 43–48. http://www.geosciencebc.com/i/pdf/SummaryofActivities2015/SoA2015_Brown.pdf
- Hayes, B.J.R., Levson, V., Carey, J. and Mykula, Y. (2016): Interpretation of Quaternary sediments and depth to bedrock, Peace Project area, northeastern British Columbia: project update; in Geoscience BC Summary of Activities 2015, Geoscience BC, Report 2016-1, p. 61–68. http://www.geosciencebc.com/i/pdf/SummaryofActivities2015/SoA2015_Hayes.pdf

GEOSCIENCE BC REPORTS

- SkyTEM Surveys ApS (2015): SkyTEM Survey: British Columbia, Canada; Data Report. Geoscience BC, Report 2016-03, 62 p. ***KEEP CONFIDENTIAL UNTIL ADVISED BY GEOSCIENCE BC THAT THE REPORT HAS BEEN RELEASED TO THE PUBLIC***. Temporary Viewing link for internal use only: http://www.geosciencebc.com.update.editmec.com/s/Report2016-03.asp?ReportID=999999999,737291&ReportIDRef=SB2J7LK3W7K1B
- Petrel Robertston Consulting Ltd. (2015): Interpretation of Quaternary Sediments and Depth to Bedrock Through Data Compilation and Correction of Gamma Logs. Geoscience BC, Report 2016-04, 24 p. ***KEEP CONFIDENTIAL UNTIL ADVISED BY GEOSCIENCE BC THAT THE REPORT HAS BEEN RELEASED TO THE PUBLIC***. Temporary Viewing link for internal use only: http://www.geosciencebc.com.update.editmec.com/s/Report2016-04.asp?ReportID=999999999,737293&ReportIDRef=1B2J7LK3W7K1D

GEOSCIENCE BC NEWS or PROMOTION

- June 16, 2015 News Release: SkyTEM Technology to Map Aquifers for Geoscience BC's Peace Project.
  http://www.geosciencebc.com/s/NewsReleases.asp?ReportID=712316&_Type=News&_Title=SkyTEM-Technology-to-Map-Aquifers-for-Geoscience-BCs-Peace-Project
- November 12, 2015 News Release: Geoscience BC present project update at CSUR Technical Luncheon.
  http://www.geosciencebc.com/s/Workshops.asp?ReportID=730531&_Type=Workshops-and-Conferences&_Title=Geoscience-BC-present-project-update-at-CSUR-Technical-Luncheon

EXTERNAL COVERAGE

Print

- Water Briefs – Water World - April 24, 2015
  http://www.waterworld.com/articles/iww/print/volume-15/issue-2/departments/water-briefs.html
- To find underground water, researchers take to the sky – May 5, 2015
  http://www.alaskahighwaynews.ca/regional-news/to-find-underground-water-researchers-take-to-the-sky-1.1874555
- North Peace groundwater surveying set to launch - July 9, 2015
  http://energeticcity.ca/article/news/2015/07/09/north-peace-groundwater-surveying-set-to-launch
- Geoscience BC Peace Project kicks off tomorrow – July 9, 2015
  http://www.cjdccountry.com/News/Story.aspx?ID=2182754
- Geoscience BC Peace Project kicks off tomorrow – July 9, 2015
  http://www.peacesunfm.com/News/story.aspx?ID=2182754
- The Peace Project, Geoscience BC to begin geophysical survey – July 9, 2015
  http://pjxmnews.me/2015/07/09/the-peace-project-geoscience-bc-to-begin-geophysical-survey/
- Geoscience BC starts mapping groundwater in the North Peace – July 13, 2015
  http://www.alaskahighwaynews.ca/regional-news/geoscience-bc-starts-mapping-groundwater-in-the-north-peace-1.1998475
- Finding water by air 350 metres deep – August 3, 2015
  Link unavailable
- Geoscience BC completes large airborne groundwater mapping project – January 20, 2016
  http://www.canadianminingjournal.com/news/water-geoscience-bc-completes-large-airborne-groundwater-mapping-project/
- Preliminary results from Geoscience's groundwater study are in – January 20, 2016
  http://energeticcity.ca/article/news/2016/01/20/91382
- Groundwater Mapping Featured at Resource Forum - January 21, 2016
  http://www.ckpg.com/2016/01/21/groundwater-mapping-featured-at-premiers/

Multimedia

- Geoscience BC Peace Project – CJDC-TV News – July 9th, 2015
  https://www.youtube.com/watch?v=eZJ_ASoBjOU
- Groundwater mapping – CKPG News – January 22, 2016
  https://www.youtube.com/watch?v=vuBNjKQ1QtE&feature=youtu.be
- Groundwater in Peace – CBC News – January 22, 2016
  P:\Communications\Media\Media Coverage\2016\CBC

EVENTS ATTENDED

- CSPG conference – Calgary, May 4-6, 2015
- Northeast Water working group meeting – Fort St John, June 10, 2015
- Peace Project kick-off event – Fort St John, July 9, 2015
- Groundwater knowledge strategy meeting – Online, September 28, 2015
- Groundwater knowledge strategy meeting – Online, October 19, 2015
- CSUR seismicity forum – Calgary, November 19
- Northeast water strategy meeting – Dawson Creek, November 26
- Regional board presentation – Dawson Creek, November 26
- Groundwater knowledge charter meeting – Online, January 7, 2016
- BC Natural Resources Forum – Prince George, January 18 -20, 2016
- Roundup – Vancouver, January 25 – 28, 2016
- Rural Roots to Resources meeting – Groundbirch, January 28, 2016
- Presentation on Groundwater mapping – Fort St John, March 3, 2016
- CSPG conference – Calgary, March 7-9, 2016

For Additional Information

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