

**LUKAS ARENSON, Dr.Sc.Techn.ETH, Dipl.Ing.ETH****Education:**

Post-Doctoral Fellow, Civil Engineering,  
University of Alberta (2007)

Dr.Sc.Techn. ETH, Civil Engineering,  
ETH Zurich (2006)

Diploma (M.Eng.), Civil Engineering,  
ETH Zurich (1997)

Vordiploma (B.Sc.), Civil Engineering,  
ETH Zurich (1997)

**Summary of Experience:**

August 2007 – Present  
Geotechnical Engineer,  
BGC Engineering Inc.

2003 – 2007  
Post-Doctoral Fellow,  
Sessional Lecturer,  
University of Alberta

1997 – 2003  
Research Assistant,  
Research Consultant,  
Teaching Assistant,  
ETH Zurich, Switzerland

1995 – 1997  
Teaching Assistant,  
Research Assistant,  
ETH Zurich, Switzerland

July – September 1995  
Trainee, Hydraulic Engineering,  
Electrowatt Engineering, Switzerland

November 1993 – February 1994  
Trainee, Structural Engineering  
Aegerter & Bosshardt Engineering,  
Switzerland

**Affiliations:**

Member:

- Canadian Geotechnical Society
- Cold Regions Geotechnical Division  
(Member at large)
- International Permafrost Association  
(PYRN Co-chair of PEWG)
- Swiss Society for Snow, Ice and  
Permafrost
- PERMOS coordination group
- Swiss Society for Soil and Rock  
Mechanics (SGBF)
- Swiss Blasting Association (SBV)

**Awards:**

Troy L. Péwé Award (2003)

Dr. Lukas Arenson's main area of expertise is geotechnical, mountain permafrost engineering with specialization on frozen soil mechanics. During his PhD in Switzerland, Dr. Arenson studied the dynamics of ice rich frozen slopes, in particular rock glaciers, from a geotechnical view point by testing original rock glacier cores and developing strength criterions. He has expert knowledge in in-situ testing and monitoring of mountain permafrost. In addition, analytical solutions were developed to analyze rock glacier stability. Later, Dr. Arenson concentrated on the thermo-mechanical processes of frozen and freezing soils on a microstructural level to better understand the strength and deformation properties of frozen soils with changing stress, temperature and salinity. He has authored a number of publications in the fields of permafrost engineering and frozen soil mechanics. He is further a reviewer of several renowned journals and conferences. Dr. Arenson counts as one of the experts in the subject of mountain permafrost.

Recently, Dr. Arenson has been studying the effects of natural air convection in cold climates to prevent permafrost degradation, to re-establish pre-construction thermal regimes after pipeline or road constructions, and to accelerate the consolidation of mine waste tailings.

Selected studies includes:

- utilizing advanced numerical modeling to model natural convective cooling processes in coarse rock fills
- analyzing water migration during frost heave and ice lens formation on a microstructural level
- performing various field investigations: core drilling in permafrost, temperature measurements, pressuremeter testing, borehole deformations, geophysical investigations
- applying the method of discrete elements to model strength of frozen soils
- Investigated the effect of solid particle characteristics on the mechanical behaviour of ice-solid mixtures
- co-developed a computer aided learning system for geotechnical engineers (CALICE). Carried out quality control of the system (content, technical ability), developed some exercises, tutorials and programmed several animations

- 2008 High Lake Project, near Kugluktuk, NU (for Zinifex Canada Inc.). Geothermal modeling for the design of tailings facility and waste rock dumps, with consideration to selecting appropriate design air temperatures and climate change scenarios including the implementation of a new surface energy balance model.
- 2008 Sewage Lagoon Project Technical Review, Cape Dorset, NU (for Nunavut Water Board). Carried out independent geothermal evaluation for water license application.
- 2008 Fort McMurray Oil Sands (Albian Sands Energy Inc.). Development of design charts to be used in the determination of tailings pipeline freeze-up times.
- 2008 Fort McMurray Oil Sands (Suncor Energy). Carried out several long term tailings consolidation modeling. Results of the consolidation modeling are used in the design of the closure plan and in the landform engineering studies.
- 2008 El Pachon Mine Site (for Xstrate plc). Reviewing of geophysical investigations and permafrost characterization in mountainous environment of the South American Andes of Argentina and Chile.
- 2008 Whistler (for the Municipality of Whistler). Design of Debris barrier. Carried out geotechnical analysis of the debris barrier foundation, GRS wall and ground anchors.
- 2007 – Pascua Lama Mine Project (for Barrick Gold Corporation). Carried out various studies on mountain permafrost, including geothermal modeling, permafrost distribution modeling, permafrost characterization, ground temperature assessment.
- 2007 – 2008 Tumbler Ridge Tunnels, BC (for CN Rail). Carried out an assessment of two railway tunnels (9 / 6 km) and designed rehabilitation measured for water control, iceing reduction and rock fall hazard mitigation.
- 2007 Pamour Pit (for Porcupine Joint Venture). Carried out coupled slope stability and seepage analysis for the staged construction of the three nations lake dam.
- 2006 Doris North Project (for Nunavut Water Board). Carried out independent review on the tailings Dam geothermal design.
- 2006 Keriko Project (for Nunavut Water Board). Carried out independent review on the geothermal design of the Long Lake Divider Dyke, Southeast Dam and West Dam.

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**TECHNICAL PUBLICATIONS****Reviewed Journal Papers**

- Arenson, L.U., Springman, S.M. and Segó, D.C. 2007. The rheology of frozen soils. *Applied Rheology* Vol. 17(1), 12147-1 – 12147-14
- Arenson, L.U. and Segó, D.C. 2006. The effect of salinity on the freezing of coarse grained sands. *Canadian Geotechnical Journal*, Vol. 43(3), 325-337.
- Arenson, L.U. and Palmer, A.C. 2005. Rock glaciers, fault gouges and asphalt. Hard particles in a nonlinear creeping matrix. *Cold Regions Science and Technology*, Vol. 43, 117-127.
- Arenson, L.U., and Springman, S.M. 2005. Triaxial constant stress and constant strain rate tests on ice-rich permafrost samples. *Canadian Geotechnical Journal*, Vol. 42(2), 412-430.
- Arenson, L.U., and Springman, S.M. 2005. Mathematical descriptions for the behaviour of ice-rich frozen soils at temperatures close to 0 °C. *Canadian Geotechnical Journal*, Vol. 42(2), 431-442.
- Arenson, L.U., Johansen, M.M., and Springman, S.M. 2004. Effects of volumetric ice content and strain rates on shear strength and creep rate under triaxial conditions for frozen soil samples. *Permafrost and Periglacial Processes*, Vol. 15(3), 261-271.
- Arenson, L.U., Hoelzle, M. and Springman, S.M. 2002. Borehole deformation measurements and internal structure of some rock glaciers in Switzerland. *Permafrost and Periglacial Processes*, Vol. 13(2), 117-135.
- Haeberli, W., Hallet, B., Arenson, L., Elconin, R., Humlum, O., Kääh, A., Kaufmann, V., Ladanyi, B., Matsuoka, N., Springman, S., and Vonder Mühl, D. 2006. Permafrost creep and rock glacier dynamics. *Permafrost and Periglacial Processes*, Vol. 17(3), 189-214.
- Arenson, L.U., Springman, S.M., and Vonder Mühl, D. The active layer index. *Permafrost and Periglacial Processes* (under revision).
- Arenson, L.U., Springman, S.M., and Phillips, M. Geotechnical considerations and guidelines for structures in mountain permafrost. *Engineering Geology* (in preparation).
- Harris, C., Arenson, L.U. Christiansen, H.H., Etzelmüller, B., Frauenfelder, R., Gruber, S., Haeberli, W. Hauck, C., Hölzle, M., Humlum, O., Isaksen, K., Kääh, A. Lehning, M. Lütschg, M.A., Matsuoka, N., Murton, J.B., Nötzli, J. Phillips, M., Ross, N., Seppälä, M. Springman, S.M., and Vonder Mühl, D. Permafrost and climate in Europe: geomorphological impacts, hazard assessment and geotechnical response. *Earth Sciences Reviews* (in press).
- Segó, D.C., Biggar, K.W., Hong, H.N., Arenson, L.U., and Kia, M. Strength and deformation characteristics of crumbed tires. *Canadian Geotechnical Journal* (submitted).
- Segó, D.C., Biggar, K.W., Hong, H.N., Arenson, L.U., and Kia, M. Hydraulic and thermal characteristics of crumbed tires. *Canadian Geotechnical Journal* (submitted).
- Segó, D.C., Biggar, K.W., Hong, H.N., Arenson, L.U., and Kia, M. Dynamic characteristics of crumbed tires. *Canadian Geotechnical Journal* (in preparation).
- Springman, S.M., Arenson, L.U., Maurer, H., Vonder Muehl, D.S., and Musil, M. Geotechnical and geophysical investigations on two rock glaciers. *Géotechnique* (in preparation).

## Dissertation

Arenson, L.U. 2002. Unstable alpine permafrost: a potentially important natural hazard - variations of geotechnical behaviour with time and temperature. Doctoral Thesis No. 14801, Institute for Geotechnical Engineering, Swiss Federal Institute of Technology, Zurich (<http://e-collection.ethbib.ethz.ch/cgi-bin/show.pl?type=diss&nr=14801>): 271p.

## Reviewed Conference Papers

Arenson, L.U., Azmatch, T.F., and Segó, D.C. 2008. A new hypothesis on ice lens formation in frost susceptible soils. In Proceedings of the 9th International Conference on Permafrost, June 29-July 3, 2008, Fairbanks, Alaska, USA. 59-64.

Arenson, L.U., Take, W.A., and Segó, D.C. 2007. Measurement of ice lens growth and soil consolidation during frost penetration using particle image velocimetry (PIV). In Proceedings of the 60th Canadian Geotechnical Conference, October 21-24, 2007, Ottawa, ON, Canada. 2046-2053.

Arenson, L.U., Pham, H.-N., Klassen, R. and Segó, D.C. 2007. Heat convection in coarse waste rock piles and tailings covers. In Proceedings of the 60th Canadian Geotechnical Conference, October 21-24, 2007, Ottawa, ON, Canada. 1500-1507.

Arenson, L.U., Chen, J.F., Pham, H.-N., and Segó, D.C. 2007. Laboratory investigations on air convection in porous media. In Proceedings of the 60th Canadian Geotechnical Conference, October 21-24, 2007, Ottawa, ON, Canada. 1836-1843.

Arenson, L.U., Doré, G., and Segó, D.C. 2007. Numerical analysis and laboratory investigations of heat drains to reduce permafrost degradation under embankments. In Proceedings of the 60th Canadian Geotechnical Conference, October 21-24, 2007, Ottawa, ON, Canada. 2054-2061.

Arenson, L.U., and Segó, D.C. 2007. Protection of mine waste and tailing ponds using cold air convection. In Proceedings of the 5th Biennial Workshop on Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates (ARCSACC), May 6-8, 2007, Edmonton, AB, Canada.

Arenson, L.U., and Segó, D.C. 2006. Considering convective air fluxes in the design of engineered structures in cold regions. In Proceedings of the 59th Canadian Geotechnical Conference, October 1-4, 2006, Vancouver, BC, Canada. 1033-1040.

Arenson, L.U., Segó, D.C., and Newman, G. 2006. The use of convective heat flow in road designs for Northern regions. In Proceedings of the Climate Change Technology Conference, May 10-12, 2006, Ottawa, Ontario, Canada. CD-Rom.

Arenson, L.U., Xia, D., Segó, D.C., and Biggar, K.W. 2006. Change in ice lens formation for saline and non-saline Devon silt as a function of temperature and pressure. In Proceedings of the 13th International Conference on Cold Regions Engineering, July 23-26, 2006, Orono, Maine, USA. CD-Rom.

Arenson, L.U., and Segó, D.C. 2006. Modeling the freezing in coarse grained sands on a microstructural level. In Proceedings of the 13th International Conference on Cold Regions Engineering, July 23-26, 2006, Orono, Maine, USA. CD-Rom.

- Arenson, L.U. and Segó, D.C. 2005. Modelling the strength of composite materials using discrete elements. In Proceedings of the 58th Canadian Geotechnical Conference 2005, September 18-21, 2005 Saskatoon, SK, Canada. CD-Rom.
- Arenson, L.U., Xia, D., Segó, D.C. and Biggar, K.W. 2005. Brine and unfrozen water migration during the freezing of Devon silt. In Proceedings of the 4th Biennial Workshop on Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates (ARCSACC), May 8-10, 2005, Edmonton, AB, Canada. pp. 35-44.
- Arenson, L.U. 2004. Numerically modeling the strength of ice using discrete elements. In Numerical Modeling in Micromechanics via Particle Methods – 2004, Proceedings of the 2nd International PFC Symposium, October 28-29, 2004, Kyoto, Japan. Edited by Y. Shimizu, R. Hart, and P. Cundall. Taylor & Francis Group, London, pp. 341-346.
- Arenson, L.U. 2004. The effect of saline pore water on the freezing of loose Devon silt. In Proceedings of the Canadian Young Geotechnical Engineers and Geoscientists Conference, October 27-30, 2004, Québec City, Québec, Canada. CD-Rom.
- Arenson, L.U. and Segó, D.C. 2004 Freezing processes for a coarse sand with varying salinities. In Proceedings of the Cold Regions Engineering & Construction Conference, May 16-19, 2004, Edmonton, Alberta, Canada. Edited by D.W. Smith, C. Lenzion and D.C. Segó. CD-Rom
- Arenson, L.U., Springman, S.M., and Hawkins, P.G. 2003. Pressuremeter tests within an active rock glacier in the Swiss Alps. In Proceedings of the Eight International Conference on Permafrost. Zurich, Switzerland, July 21-25. Edited by M. Phillips, S.M. Springman, and L.U. Arenson. A.A. Balkema, Vol. 1, pp. 33-38.
- Arenson, L.U., Almasi, N., and Springman, S.M. 2003. Shearing response of ice-rich rock glacier material. In Proceedings of the Eight International Conference on Permafrost. Zurich, Switzerland, July 21-25. Edited by M. Phillips, S.M. Springman, and L.U. Arenson. A.A. Balkema, Vol. 1, pp. 39-44.
- Arenson, L.U. 2002. First results of triaxial creep tests on permafrost soil samples. In Proceedings of the International Workshop on Constitutive and Centrifuge Geotechnical Modelling: Two Extremes, S. Springman (ed.), A.A. Balkema. 285-290.
- Arenson, L.U. and Springman, S.M. 1998. Geotechnik und Alpiner Permafrost in der Schweiz. Mitteilung der Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie ETH Zürich, No. 158, 168-177.
- Azmatch, T.F., Arenson, L.U., Segó, D.C., and Biggar, K.W. 2008. Measuring ice lens growth and development of soil strains during frost penetration using particle image velocimetry (GeoPIV). In Proceedings of the 9th International Conference on Permafrost, June 29-July 3, 2008, Fairbanks, Alaska, USA. 89-93.
- Klassen, R., Arenson, L.U., Segó, D.C., and Biggar, K.W. 2007. Heat convection modeling in waste rock piles. In Proceedings of the 5th Biennial Workshop on Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates (ARCSACC), May 6-8, 2007, Edmonton, AB, Canada.
- Maurer, H., Springman, S.M., Arenson, L.U., Musil, M., and Vonder Mühl, D.S. 2003. Characterisation of potentially unstable mountain permafrost - A multidisciplinary approach. In Proceedings of the Eight International Conference on Permafrost. Zurich, Switzerland, July 21-25. Edited by M. Phillips, S.M. Springman, and L.U. Arenson. A.A. Balkema, Vol. 2, pp. 741-746.

- Nater, P., Arenson, L.U., and Springman, S.M. 2008. Choosing geotechnical parameters for slope stability assessments in alpine permafrost soils. In Proceedings of the 9th International Conference on Permafrost, June 29-July 3, 2008, Fairbanks, Alaska, USA. 1261-1266.
- Nguyen, D.A., Arenson, L.U., Segó, D.C., and Biggar, K.W. 2008. Unconfined compressive strength of frozen saline sand under low cooling rate. In Proceedings of the 61th Canadian Geotechnical Conference, September 21-24, 2007, Edmonton, AB, Canada. Submitted.
- Nguyen, D.A., Arenson, L.U., and Segó, D.C. 2007. Salinity rejection in sand as an effect of the freezing direction. In Proceedings of the 60th Canadian Geotechnical Conference, October 21-24, 2007, Ottawa, ON, Canada. 2040-2045.
- Nguyen, D.A., Arenson, L.U., Segó, D.C., and Biggar, K.W. 2006. Strength variations within artificially frozen soils. In Proceedings of the 59th Canadian Geotechnical Conference, October 1-4, 2006, Vancouver, BC, Canada. 1048-1053.
- Nguyen, D.A., Arenson, L.U., Segó, D.C., and Biggar, K.W. 2006. Dependence of soil salinity measurements on temperature and probe length. In Proceedings of the 13th International Conference on Cold Regions Engineering, July 23-26, 2006, Orono, Maine, USA. CD-Rom.
- Pham, H.-N., Arenson, L.U., and Segó, D.C. 2008. Convective heat transfer in waste rock piles under permafrost environment. In Proceedings of the 61th Canadian Geotechnical Conference, September 21-24, 2007, Edmonton, AB, Canada. 940-947.
- Pham, H.-N., Arenson, L.U., and Segó, D.C. 2008. Numerical analysis of forced and natural convection in waste-rock piles in permafrost environments. In Proceedings of the 9th International Conference on Permafrost, June 29-July 3, 2008, Fairbanks, Alaska, USA. 1411-1416.
- Springman, S.M. and Arenson, L.U. 2008. Recent advances in permafrost geotechnics. In Proceedings of the 9th International Conference on Permafrost, June 29-July 3, 2008, Fairbanks, Alaska, USA. 1685-1694.
- Vonder Mühl, D.S., Arenson, L.U., Hoelzle, M., Nötzli, J., and Springman, S.M. 2005. Comparison between the PERMOS sites Murtèl and Schilthorn: Similarities and differences of the temperature regime. In Proceedings of the 2nd European Conference on Permafrost, June 12-16, 2005 Potsdam, Germany. CD-Rom.
- Vonder Mühl, D.S., Arenson, L.U., and Springman, S.M. 2003. Temperature conditions in two Alpine rock glaciers. In Proceedings of the Eight International Conference on Permafrost. Zurich, Switzerland, July 21-25. Edited by M. Phillips, S.M. Springman, and L.U. Arenson. A.A. Balkema, Vol. 2, pp. 1195-1200.
- Xia, D., Arenson, L.U., Biggar, K.W., and Segó, D.C. 2005. Freezing process in Devon Silt - Using time laps photography. In Proceedings of the 58th Canadian Geotechnical Conference 2005, September 18-21, 2005 Saskatoon, SK, Canada. CD-Rom.
- Yasufuku, N., Springman, S.M., Arenson, L.U. and Ramholt, T. 2003. Stress-dilatancy behaviour of frozen sand in direct shear. In Proceedings of the Eight International Conference on Permafrost. Zurich, Switzerland, July 21-25. Edited by M. Phillips, S.M. Springman, and L.U. Arenson. A.A. Balkema, Vol. 2, pp. 1253-1258.

**Extended Abstracts**

Arenson, L.U., and Segó, D.C. 2007. Cooling of pipeline and road ROWs using cold air convection. GAC-MAC Conference. May 23-25, 2007. Yellowknife, NWT, Canada.

Arenson, L.U., Nater, P., and Springman, S.M. 2006. On the stability of rock glaciers under a global warming scenario: facts and fiction. 4th Swiss Geoscience Meeting, November 24-25, 2006, Bern, Switzerland.

Arenson, L.U., Nguyen, D.A., Xia, D., Segó D.C., and Biggar, K.W. 2006. Influence of solute dynamics on natural and artificial freezing of sand and silt. In Proceedings of the 5th International Conference on Contaminants in Freezing Ground, May 21-25, 2006, Oslo, Norway.

Arenson, L.U., Vonder Mühll, D.S. and Springman, S.M. 2005. The effect of the summer heatwave 2003 on the temperatures of the rock glacier Muragl, Swiss Alps. In Proceedings of the 2nd European Conference on Permafrost, June 12-16, 2005, Potsdam, Germany.

Cassie, J. and Arenson, L.U. 2008. Thermal regime within an arctic waste dump: Observations and implications. In Proceedings of the 9th International Conference on Permafrost, June 29-July 3, 2008, Fairbanks, Alaska, USA. 41-42.

Johansen, M.M., and Arenson, L.U. 2003. Effects of volumetric ice content and strain rates on shear strength and creep rate under triaxial conditions for frozen soil samples. In Eight International Conference on Permafrost Extended Abstracts on Current Research and Newly Available Information. Edited by W. Haeberli, and D. Brandova. 71-72.

Springman, S.M. and Arenson, L.U. 1998. Some geotechnical influences on thawing Alpine permafrost. In Proceedings of the Seventh International Conference on Permafrost. Yellowknife, NWT, Canada (Program, Abstracts & IPA Reports). 197-198.

**Proceedings Editor**

Phillips, M., Springman, S.M. and Arenson, L.U. 2003. Proceedings of the Eight International Conference on Permafrost. Zurich, Switzerland, July 21-25. A.A. Balkema: 1322p.

**Book Chapters**

Arenson, L.U., Springman S.M., and Phillips, M. 2008. Geotechnical Considerations and Technical Solutions for Infrastructure in Mountain Permafrost. Nova Science Publishers, Inc., Hauppauge, NY, USA. (under review).

**Varia**

Arenson, L.U. 2005. Use miniature fibre optic pore pressure sensors in geotechnical laboratory testing. Internal Report, UofA Geotechnical Centre, 28p.

Arenson, L.U. 2003. A summer in Edmonton. UofA Geotechnical Centre Report 2003: 12. [http://www.uofaweb.ualberta.ca/geotechnical/pdfs/2003\\_NewsLetter.pdf](http://www.uofaweb.ualberta.ca/geotechnical/pdfs/2003_NewsLetter.pdf)

Springman, S.M., and Arenson, L.U. 2003. Wenn Wasser die Erde ins Rutschen bringt. BULLETIN ETH Zürich, Nr. 289, May: 36-39. [http://www.cc.ethz.ch/bulletin/2003/eth\\_bulletin\\_289.pdf](http://www.cc.ethz.ch/bulletin/2003/eth_bulletin_289.pdf)

Keller, F., Ammann, W., Arenson, L.U., Frauenfelder, R., Gruber, S., Haeberli, W., Hansen, S., Ikeda, A., Kääh, A., Kneisel, C., Lütschg, M., Maisch, M., Matsuoka, N., Maurer, H. Musil, M., Phillips, M., Springman, S.M., Stocker-Mittaz, C., Schläpfer, D., Thalparpan, T., Vonder Mühl, D. 2003. Field Guide Upper Engadin, Eight International Conference on Permafrost. Zurich, Switzerland, July 21-25.

Phillips, M., Arenson, L.U., Kääh, A. and Hoelzle, M. (2002). Dem Permafrost oberhalb von Pontresina auf der Spur – Vielfältige Untersuchungen geben Aufschluss über den Zustand des Blockgletschers. Bündnerwald Vol. 55, 79- 83.

Springman, S.M. and Arenson, L.U. 2001. Forschungsprojekte im Oberengadin 1998-2000. Mitteilungen der Schweizerischen Gesellschaft für Boden- und Felsmechanik, No. 141, 85-93.

Arenson, L.U. 2001. Triaxiale Kriechversuche an gefrorenen Bodenproben. 3. GEODACH Treffen, Stuttgart, 99-105.

Arenson, L.U. 2001. Hydromechanisch gekoppelte Prozesse in Permafrost und Moräneablagerungen. Nachdiplomkurs in angewandten Erdwissenschaften, 9p.

Arenson, L. and Springman, S.M. 2000. Slope stability and related problems of Alpine permafrost. In Proceedings of the International Workshop on Permafrost Engineering, Longyearbyen, Svalbard, Norway, 185-196.

Arenson, L.U. 2000. Verformungsmessung im Blockgletscher Muragl, Installation der Inklinometerrohre. Institut für Geotechnik, Bericht Nr. I 451/1, 23p.

Arenson, L.U. 2000. Fortschritte beim ETH-Projekt im Val Muragl. La Padella, 5-6.

**Poster Presentations**

Azmatch, T.F., Arenson, L.U., Sego, D.C., and Biggar, K.W. 2008. Measuring ice lens growth and development of soil strains during frost penetration using particle image velocimetry (GeoPIV). 9th International Conference on Permafrost, June 29-July 3, 2007, Fairbanks, Alaska, USA1.

Cassie, J. and Arenson, L.U. 2008. Thermal regime within an arctic waste dump: Observations and implications. 9th International Conference on Permafrost, June 29-July 3, 2008, Fairbanks, Alaska, USA.

Pham, H.-N., Arenson, L.U., and Sego, D.C. 2008. Numerical analysis of forced and natural convection in waste-rock piles in permafrost environments. 9th International Conference on Permafrost, June 29-July 3, 2008, Fairbanks, Alaska, USA.

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<sup>1</sup> Winner of the PYRN best poster award



- Nguyen, D.A., Arenson, L.U., Segó D.C., and Biggar, K.W. 2007. Strength variation in frozen saline sand as a function of freezing regime. 15th Annual University of Alberta Graduate Student Poster Night, March 15, Edmonton, AB, Canada.
- Arenson, L.U., Nguyen, D.A., Xia, D., Segó D.C., and Biggar, K.W. 2006. Influence of solute dynamics on natural and artificial freezing of sand and silt. In Proceedings of the 5th International Conference on Contaminants in Freezing Ground, May 21-25, 2006, Oslo, Norway.<sup>2</sup>
- Arenson, L.U. 2005. Modelling the mechanical properties of frozen soils. UofA Postdoctoral Fellow Research Day. April 1, Edmonton, AB, Canada.
- Xia, D., Arenson, L.U. and Segó, D.C. 2004. Frost heave in Devon silt and MFTs. CONRAD Tailings Seminar. November 8, Edmonton, AB, Canada.
- Arenson, L.U., Almasi, N., and Springman, S.M. 2003. Shearing response of ice-rich rock glacier material. Eight International Conference on Permafrost. July 21-25, Zurich, Switzerland.
- Arenson, L.U. 2003. Rock Glacier Muragl. Pre-Conference Field Excursion, Eight International Conference on Permafrost. July 21-25, Zurich, Switzerland.
- Arenson, L.U. 2003. Rock Glacier Murtèl-Corvatsch. Pre-Conference Field Excursion, Eight International Conference on Permafrost. July 21-25, Zurich, Switzerland.
- Johansen, M.M. and Arenson, L.U. 2003. Effects of volumetric ice content and strain rates on shear strength and creep rate under triaxial conditions for frozen soil samples. Eight International Conference on Permafrost. July 21-25, Zurich, Switzerland.
- Vonder Mühl, D.S., Arenson, L.U. and Springman, S.M. 2003. Temperature conditions in two Alpine rock glaciers. Eight International Conference on Permafrost. July 21-25, Zurich, Switzerland.
- Arenson, L.U. and Springman, S.M. 2001. Pressuremeter tests in the Murtèl-Corvatsch rock glacier, Upper Engadin, Switzerland. First European Permafrost Conference. March 26-28, Rome, Italy.
- Arenson, L.U., Hoelzle M. and Springman, S.M. 2000. Borehole deformation measurements in Alpine rock glaciers. First European Permafrost Conference. March 26-28, Rome, Italy.
- Springman, S.M. and Arenson, L.U. 1998. Some geotechnical influences on thawing Alpine permafrost. Seventh International Conference on Permafrost. June 23-27, Yellowknife, NWT, Canada.
- Arenson L.U. and Springman, S.M. 1997. Geotechnik und Alpiner Permafrost in der Schweiz, Annual Assembly of the Swiss Geomorphological Society. July 4-6, Samedan, Switzerland.

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<sup>2</sup> Winner of the best poster

### TECHNICAL ACTIVITIES

- Since 2005 Cold Regions Geotechnical Division (Member at large)
- Since 2008- PYRN Co-chair of the International Permafrost Association Permafrost Engineering Working Group
- Reviewer for the *Canadian Geotechnical Journal*
- Reviewer for *Environmental Science & Technology*
- Reviewer for the *Journal of Geophysical Research - Earth Surface*
- Reviewer for *Polar Record*
- Reviewer for *Permafrost and Periglacial Processes*
- Reviewer for *Engineering Geology*
- Reviewer for *Landslides: Journal of International Consortium on Landslides*
- Reviewer for the *North American Conference on Landslides*
- Reviewer for the *Cold Regions Engineering & Construction Conference, May 2004, Edmonton, AB, Canada*
- Co-editor for the *8th International Conference on Permafrost, July 2003, Zurich, Switzerland*
- Reviewer and review editor for the *8th International Conference on Permafrost, July 2003, Zurich, Switzerland*
- Associate editor and reviewer for the *9th International Conference on Permafrost, June 29 – July 3, 2008, Fairbanks, Alaska*

### THESES CO-SUPERVISED

#### PhD

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|------|---------------|--|
| 2009 | Firew Azmatch | Ice Lens Formations and Frost Heave in Frost Susceptible   |
| 2009 | Pham          | Numerical Modelling of Heat Convection in Porous Media     |
| 2009 | Kia           | Towards Measurements of Effective Stresses in Frozen Soils |
| 2009 | Nguyen        | Freeze Thaw Influence on Residual Stress                   |

#### MSc. / MEng.

- |      |          |  |
|------|----------|--|
| 2009 | Klassen  | Convective Cooling of Waste Rock Piles, Diavik Mine, NWT   |
| 2007 | Pham     | Uniaxial Compression Tests on Saline Frozen Soils  |
| 2006 | Xia      | Frost Heave Studies Using Digital Photographic Technique   |
| 2002 | Johansen | Effect of volumetric ice content and strain rates on shear strength and creep rate under triaxial conditions for frozen soil samples |
| 2002 | Andersen | Comparison of shear strength of different frozen and unfrozen moraine materials with direct shear box testing                        |

**Diploma thesis (MEng.)**

2003	Betschart, Hallier, Lopez, and Fischer	Schadensanierung Rüdlingen SH – Projekt Graben
2001	Almasi	Kriechen in Permafrost
1999	Bertola	Slope stability analysis of nailed excavations
1998	Gfeller, Heigold, Imboden, and Schütz	Müllverbrennungsanlage Berlin:

**COURSES TAUGHT AT UofA**

EngG 130	Undergraduate Course:	Engineering Mechanics
CivE 250	Undergraduate Course:	Survey School (field course)
CivE 381	Undergraduate Course	Soil Mechanics
CivE 694	Graduate Course:	Permafrost Engineering (section on numerical modeling)
CivE695	Graduate Course	Soil Structures

**INDUSTRIAL SHORT COURSES TAUGHT**

2007	Permafrost Engineering (UofA)
2007	Heat Convection - ARCSACC (UofA)
2006	Permafrost Engineering (UofA)
2005	Permafrost Engineering (UofA)

**KEVIN BIGGAR, Ph.D., P.Eng**  
*Senior Geotechnical/Geoenvironmental Engineer***Education:**

B.Eng. Civil Engineering,  
Royal Military College of Canada  
Kingston, ON, 1979

Ph.D. Geotechnical Engineering,  
University of Alberta - 1991

**Summary of Experience:**

28 years of project and personnel  
management

20 years in permafrost and frozen  
ground engineering

15 years in geoenvironmental  
engineering including contaminated  
site assessment and remediation,  
mine waste management

10 years in horizontal directional  
drilling for geotechnical and  
geoenvironmental applications

**Affiliations:**

Professional Engineer, Assoc. of  
Prof. Engineers, Geologists and  
Geophysicists of Alberta.

Adjunct Professor, University of  
Alberta, Geotechnical and  
Geoenvironmental Engineering

Executive Member, Contaminants  
in Frozen Ground Committee

Member, Canadian Geotechnical  
Society

Member, Geotechnical Society of  
Edmonton

Dr. Kevin Biggar is a Senior Geotechnical and Geoenvironmental Engineer and has worked in the Arctic since 1981. He has extensive experience in permafrost and frozen ground engineering, assessment and remediation of contaminated sites in Arctic and cold climates. His experience includes project and personnel management and supervision spanning 20 years of military service, 16 years of academic experience as a university professor and numerous consulting assignments. He has published more than 40 journal and 80 conference papers, the majority of which are related to cold regions, mine wastes, and contaminated site assessment and remediation. He has taught permafrost engineering as graduate and industrial courses since 1992. He also organized and chaired 6 conferences related to assessment and remediation of contaminated sites in the Arctic. His research in cold regions and freezing applications in engineering have won the Roger Brown and RM Quigley Awards from the Canadian Geotechnical Society, the Keefer Medal from the Canadian Society of Civil Engineering, the ASTech Innovation Award, and the APEGGA Summit Environmental Excellence Award.

- 2007 – ongoing. Ammonium Sulfate Storage Building groundwater collection system (for Sherritt International – Fort Saskatchewan, AB) Investigation and design for contaminated groundwater collection system for ammonium sulphate storage building.
- 2007 – ongoing Dam Safety Review (for Albian Sands Energy) Team lead for dam safety review for ASE External Tailings Facility (ETF)
- 2007 - Donlin Creek Mine (for Barrick Gold Corporation) Finalize plant site foundation design parameters, evaluate impacts of thaw consolidation beneath waste dumps, evaluate geosynthetic liner deformations beneath ice-rich sediments in tailings pond, senior review of laboratory test results on permafrost soils, design and oversee strength testing on frozen soil samples for the Donlin Creek Gold Mine in Alaska.
- 2007 - Technical Review Windy Lake Project (for Nunavut Water Board) Technical review to assess the landfarm (or land treatment area (LTA)) design and implementation for project 2BE-HOP / Miramar Hope Bay Ltd. / Hope Bay Windy Lake Project - Review of License Renewal Application.

- 2007 - Technical Review Jericho Mine Project (for Nunavut Water Board) Technical evaluation, support and advice addressing landfill design, waste and hazardous materials management plan, Jericho diamond mine, Tahera Diamond Corporation Inc.
- 2006 - Cold Climate Bioremediation: A Review of Field Case Histories (for Environment Canada, Assessment and Monitoring, Yellowknife.) Supervised the background research and preparation of report to Env. Canada to aid in the development of guidelines for bioremediation in Arctic sites.
- 2005 - Impact of Cold Temperatures on Biodegradation Rates for Natural Attenuation of Petroleum Hydrocarbons. (for Alberta Environment, Water Research Users Group) Supervised the background research and preparation of report to AENV to aid in the development of guidelines for implementation of natural attenuation at oil and gas contaminated sites.
- 2005 - Identification of the Effects of Salt on the Natural Attenuation of Petroleum Hydrocarbons. (for Alberta Environment, Water Research Users Group) Supervised a laboratory research program and report preparation on impacts of salt on bioremediation, to aid in the development of guidelines for implementation of natural attenuation at oil and gas contaminated sites.
- 2005-present: Convection cooling in waste rock piles at Daivik mine. (U of A research program) Working in conjunction with Dr. D.C. Segó and Dr. D. Blowes studying convection cooling in waste rock piles, to evaluate the potential for ARD in permafrost regions.
- 2004 - Contaminant movement in permafrost and the active layer. (for Environment Canada, Environmental Protection, Yellowknife). Report written based on many years of research and background information on how contaminants move in permafrost environments.
- 2004 - Gasoline spill migration into frozen ground (for Gartner Lee Ltd.) Expert review to evaluate the potential for spilled gasoline to migrate into frozen ground following a large spill in Ontario.
- 2004-present: Investigation of hydrocarbon contamination fate and transport in permafrost fractured bedrock at the Colomac Mine, NWT. (for DIAND Northern Contaminated Sites Program). Expert review and implementation of PhD research program to study how to deal with fuel spill contamination into fractured bedrock at the Colomac mine.
- 1997 – 2004: Intrinsic bioremediation study of BTEX and chlorinated solvents 4 Wing Cold Lake.(for Dept. of National Defence) Implementation of research program to study natural attenuation of contaminants at 4 sites at CFB Cold Lake: Main fuel storage compound, former gasoline service station, fire fighter training area, and former landfill containing both fuel and chlorinated solvent contamination.
- 2004-present: Geostatistical interpretation and modeling for natural attenuation assessment (U of A research program) Implementation of PhD research program to combine geostatistical analysis and fate and transport modelling to study natural attenuation at upstream oil and gas contaminated sites in Alberta.
- 2004 – 2005: Trickle-discharge freeze separation to treat tailings water (U of A research project) MSc research project to study the mechanism of trickle discharge freeze separation, and evaluate the viability to use it on a large scale for oil sands tailings water treatment.
- 2004 – 2005: Use of waste sulfur for haul roads in oil sands sites (U of A research project) MSc research project with D. Segó to study the viability of using sulphurcrete for haul road bases instead of crushed limestone.

- 2004 - present: Impact of ground freezing on solute redistribution and strength in frozen soils (U of a research project) PhD research project with D. Segó to study solute redistribution during ground freezing applications, and its impact on soil strength.
- 2003 – 2007: Drilling mud sumps performance in permafrost in the Mackenzie Delta. (for Environment Canada, Canadian Wildlife Services). Background research field study to examine if contaminants are moving out of old drilling mud sumps in permafrost regions. Involved field drilling program to gather soil cores, then laboratory sectioning of the cores to measure their physical and chemical properties.
- 2003 – 2007: Improvement of ultraviolet induced fluorescence cone penetration test to characterize free phase hydrocarbons in the subsurface. (U of A research program with ConeTec Investigations) Industry sponsored PhD research project to develop an improved UVIF sensor system to characterize hydrocarbon contamination in the subsurface.
- 2002 - Evaluation of site characterization and groundwater sampling methods to support monitored natural attenuation (for Alberta Environment). Implemented literature review and report prepared to aid in preparation of guidelines for natural attenuation implementation in Alberta. 2002-2003: study of spray freezing to treat tailings water.
- 2001 – 2006: Conduct, supervise, and review of soil and groundwater investigations at numerous (> 20) upstream oil and gas facilities. Some with the University of Alberta research on natural attenuation, others when working on sabbatical with Komex International as the head of the newly formed remediation group.
- 2001-present: Studies on impacts of various sampling strategies and equipment on natural attenuation interpretation. (U of A research program) Principal investigator for NSERC Collaborative Research and Development project titled (Consortium for Research on Natural Attenuation (CORONA) at upstream oil and gas sites). This component looked at spatial, temporal and sampling induced variability in measured concentrations of various chemical species in groundwater samples.
- 1998 - 1999: Acid mine generation in permafrost regions. (U of A research project) MSc research project to examine the potential for acid generation in tailings at sub-zero temperatures.
- 1999 - State-of-the-art report on bioremediation of DDT contaminated soils. (for Indian and Northern Affairs Canada, Renewable Resources, Waste Management.) Implemented literature review and report preparation with Dr. J Foght to address the viability for biological degradation of DDT.
- 1999 - 2000: Invited expert for workshop to study landfilling of PCB amended painted materials at DEW Line sites. (for DND).
- 1997 - 2000: Use of plants to dewater and strengthen oil sands CT. (U of A research project) With D. Segó, D. Chanasyk, and A. Naeth implemented PhD research project to determine the viability of using plants to remove water from oil sands very saline composite tailings.
- 1997 - 1998: Effects of hydrocarbon spills on utility services, (for Edmonton utility companies.) Implement background research and oversee report preparation to evaluate how spilled hydrocarbons will impact buried utilities.

- 1997 - Freezing Ground Tunnel Jacking Laboratory Test Program. (For Muesler Rutledge Consulting Engineers) Oversee laboratory test program and report preparation to evaluate frozen soil strengths and deformations for ground freezing project on the Boston arterial ring road project where it had to pass beneath the Boston rail yards.
- 1997 - Fundamental behaviour of oil sands mature fine tailings. (U of A research project) MSc research project with D. Seago and D. Scott implementing scanning electron microscopy to study oil sands MFT structure under various treatment conditions.
- 1996 – Contaminant movement in permafrost at Isachsen High Arctic Weather Station (U of A research project) Supervised M.Eng study (of M. Nahir) to examine fuel spill migration in permafrost at Isachsen HAWS.
- 1995 - Effects of anaerobic biodegradation on porous media permeability. (Royal Military College, Kingston research program) MSc research program with J. Heroux to study reductions in soil permeability with anaerobic biofilm growth, to study the potential impacts of anaerobic bioremediation on groundwater flow.
- 1995 - Critical factors affecting soil vapour extraction efficiency. (Royal Military College, Kingston research program) MSc research program to examine the factors that affect soil vapour extraction efficiency.
- 1995 – 1999: Canadian Liquefaction Experiment (U of A research project) Research associate responsible for field ground freezing to obtain undisturbed loose sand samples to evaluate liquefaction potential.
- 1994 - 1995: Resolution of electrical grounding problems in permafrost (for DND) While at RMC, Kingston conducted research and provided advice on ways to improve electrical grounding at DND facilities in permafrost regions.
- 1993 - 1995 - Development of an expert system for soil and groundwater remediation technology selection (for DND) Supervised research associate developing a computer-based expert system for remediation technology selection.
- 1994 - Effects of Oil Spills on Permafrost (for SINTEF Geotechnical Engineering, Trondheim, Norway) Report preparation on state-of-the-art understanding of how spilled fuels migrate in permafrost regions.
- 1994 - Landfarming to treat diesel contaminated soil (Royal Military College, Kingston research program) MSc research program to study land treatment to remediate diesel contamination in sands at CFB Borden.
- 1993 - Compilation of a geotechnical database for Short Range Radar construction (for DND, NDHQ/North Warning System Office) Consolidation of all data and development of computer database from all the consulting reports associated with the Short Range Radar construction at 40 sites.
- 1993 - Site investigation (soil and groundwater) at a former service station, an operating vehicle pool fueling site, and a landfill at CFB Borden (for DND). Implementation of field investigations at 3 contaminated sites at CFB Borden.
- 1992 -1993: Barrel remediation program, CFS Alert (for DND, CFCCHQ/SSO Tech Svcs.) Reconnaissance and supervision of a program to sample, catalogue and analyze the contents of more than 1200, 200L barrels of waste liquid at CFS Alert.
- 1994 - 1995 – Contaminant movement in permafrost at CFS Alert (for DND) Implemented a field and laboratory study to examine fuel spill migration in permafrost at 3 sites at CFS Alert.

- 1992: Site investigation (soil and groundwater) of two fuel spill sites at CFB St. Jean, PQ. (for DND) Implementation of field investigations at 2 contaminated sites at CFB St Jean, PQ.
- 1989 - Short Range Radar pile installation and testing (for DND/DCC) Site engineer with Bot Construction Ltd. Responsible for installation and testing of piles at the first 3 SRR sites constructed by DND/DCC.
- 1988 - 1991: Pile design in permafrost (U of A research project) Conducted my own Ph.D. research related to piling operations in the Arctic for DND's Short Range Radar System. Developed design guidelines for piles in saline permafrost. Developed the mix design for Sika's Arctic 100 grout.
- 1981 Operation CESAR field trials (for DND) Organized and supervised ice-blasting and flooding experiments on the pack ice outside Resolute, NWT for DND in preparation for the 1982 austere airstrip development for airborne operations in support of Canadian Exploration of the Sub-sea Alpha Ridge.

## Technical Publications

### Proceedings (Editor)

- Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates. 2007. Edmonton, 6 -8 May.  
With M. Nahir & G. Cotta.
- Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates. 2005. Edmonton, 8-10 May.  
With M. Nahir & G. Cotta. p. 336.
- Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates. 2003. Edmonton, 4-6 May.  
With M. Nahir & G. Cotta. p. 396.
- Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates. 2001. Edmonton, 7-8 May.  
With M. Nahir & G. Cotta. p. 306.
- Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates. 1999. Edmonton, 3-4 May.  
With M. Nahir. p. 206.
- Joint Canada/US, Military/Civilian Workshop on technologies and techniques for hydrocarbon remediation in cold and Arctic climates. 1995. Royal Military College of Canada, Kingston, Ontario, June 6-7.

## Journal and Conference Publications

### Permafrost and Cold Regions Engineering

- Iwakun, O., Biggar, K.W., Van Stempvoort, D., Bickerton, G., and Voralek, J. 2007. Fuel contamination characterization in permafrost fractured bedrock, at the Colomac mine site. Cold Regions Science and Technology, doi:10.1016/j.coldregions.2007.10.001
- Van Stempvoort, D., and Biggar, K.W. 2007. Potential for bioremediation of petroleum hydrocarbons in groundwater under cold climate conditions: A review. Cold Regions Science and Technology, doi:10.1016/j.coldregions.2007.06.009
- Beier, N., Sego, D., Donahue, R., and Biggar, K. 2007. Trickle-freeze separation of contaminants from saline waste water. International Journal of Mining, Reclamation and Environment, **21:2**,(144-156).
- Beier, N. Sego, D.C., Donahue, R. and Biggar, K. 2007. Laboratory investigation on freeze separation of saline mine waste water. Cold Regions Science and Technology, 48 (239-247).



- Iwakun, O., Biggar, K.W., 2007. Behavior of spilled petroleum hydrocarbon at Colomac mine site, NWT Proceedings, 60th Canadian Geotechnical Conference and 8th Joint CGS/IAH-CNC Groundwater Conference in Ottawa, Canada, October 21-24, pp. 2106-2114.
- Bickerton, G, Van Stempvoort, D.R., Voralek, J., and Biggar, K.W. 2007 Hydrogeological setting of petroleum contamination at Colomac mine NWT, A permafrost region of the Canadian Shield. Proceedings, 60th Canadian Geotechnical Conference and 8th Joint CGS/IAH-CNC Groundwater Conference in Ottawa, Canada, October 21-24, pp. 333-340.
- Nguyen, A.D., Arenson, L.U., Segó, D.C., and Biggar, K.W. 2007 Salinity rejection in sand as an effect of the freezing direction. Proceedings, 60th Canadian Geotechnical Conference and 8th Joint CGS/IAH-CNC Groundwater Conference in Ottawa, Canada, October 21-24, pp. 2040-2045.
- Iwakun, O., Biggar, K.W., Van Stempvoort, D.R., 2007 Fuel contamination characterization in permafrost fractured bedrock at the Colomac mine site (NWT). Proceedings, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, Edmonton, AB. May 4-6.
- Klassen, R., Arenson, L.U., Segó, D.C., Biggar, K.W. 2007. Heat Convection Modeling in Waste Rock Piles. Proceedings, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, Edmonton, AB. May 4-6.
- Iwakun, O., Biggar, K.W., Van Stempvoort, D., Bickerton, G., and Voralek, J. 2006. Fuel contamination characterization in permafrost fractured bedrock at the Colomac mine site, NWT. Proceedings, 59<sup>th</sup> Canadian Geotechnical Conference, Vancouver, BC. 1-4 October. Paper No. 261, 8p.
- Ulrich, A.C., Biggar, K.W., Armstrong, J.E., Van Stempvoort, D., Tappenden, K., and Rogers, P. 2006. Impact of cold temperatures on biodegradation rates. Proceedings, 59<sup>th</sup> Canadian Geotechnical Conference, Vancouver, BC. 1-4 October. Paper No. 484, Paper No. 261, 8p.
- Nguyen, D. A., Arenson, L. U., Segó, D. C. and Biggar, K. W. 2006. Strength variations within artificially frozen soil. Proceedings, 59<sup>th</sup> Canadian Geotechnical Conference, Vancouver, BC. 1-4 October. 6p.
- Nguyen, D. A., Arenson, L. U., Segó, D. C. and Biggar, K. W. 2006. Dependence of Soil Salinity Measurements on Temperature and Probe Length. Proceedings, ASCE Cold Regions Engineering Conference. p.10.
- Arenson, L. U., Xia, D., Segó, D. C. and Biggar, K.W. 2006. Change in ice lens formation for saline and non-saline Devon silt as a function of temperature and pressure. Proceedings, ASCE Cold Regions Engineering Conference. p.11.
- Xia, D., Arenson, L.U., Biggar, K.W., and Segó, D.C., 2005. Freezing process in Devon Silt - Using time-lapse photography. Proceedings, 58<sup>th</sup> Canadian Geotechnical Conference, Saskatoon, SK., 8p.
- Arenson, L., Xia, D., Segó, D. and Biggar, K., 2005. Brine and Unfrozen Water Migration During the Freezing of Devon Silt, Proceedings, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, Edmonton, AB, May 7-10, pp. 35-44.
- Biggar, K.W., Donahue, R., Segó, D.C., Johnson, M., and Birch, S. 2004. Spray Freezing Decontamination of Tailings Water at the Colomac Mine. Cold Regions Science and Technology, 24:106-119.
- Segó, D.C., Biggar, K.W., and Wong, G. 2003, Enlarged Base (Belled) Piles for use in ice or ice-rich permafrost., ASCE Journal of Cold Regions Engineering, 17(2):68-88.

Biggar, K.W., and Kong, V. 2001. An analysis of long-term pile load tests in permafrost from the short Range Radar Site foundations. *Canadian Geotechnical Journal*, **38:3**, 441-460.

Biggar, K.W., and Nahir, M. 1999. The behaviour of petroleum spills in permafrost soils.

Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates. Edmonton, 3-4 May. pp. 45 - 51.

McKenna, J.K. and Biggar, K.W. 1998. The rehabilitation of a passive ventilated slab on grade foundation using horizontal thermosyphons. *Canadian Geotechnical Journal*, **35:4**, pp 678 - 691.

Biggar, K.W., Segó, D.C. and Stahl, R. 1996 The performance of a long-term pile load testing system in saline and ice-rich permafrost. *ASCE Cold Regions Journal* Vol 10 No. 3. pp. 149-162.

Biggar, K.W. and Segó, D.C. 1994. Time dependent displacement behavior of model adfreeze and grouted piles in saline permafrost. *Canadian Geotechnical Journal* 31:395-406.

Biggar, K.W., Segó, D.C. and Noel, M.M. 1993. Laboratory and field performance of high alumina cement based grout for piling in permafrost. *Canadian Journal of Civil Engineering*, 20:101106.

Biggar, K.W. and Segó, D.C. 1993. Field pile load tests in saline permafrost, Part I, Test procedure and results. *Canadian Geotechnical Journal* 30: 34-45.

Biggar, K.W. and Segó, D.C. 1993. Field pile load tests in saline permafrost, Part II, Analysis of results. *Canadian Geotechnical Journal* 30: 46-59.

Biggar, K.W. and Segó, D.C. 1993. Strength and deformation behavior of model adfreeze and grouted piles in saline permafrost. *Canadian Geotechnical Journal* 30: 319-337.

Biggar, K.W., Hivon E.G. and Segó, D.C., 1993. Time dependent displacement of piles in saline permafrost. PERMAFROST, 6th International Conference on Permafrost, Beijing, China, 59 July, 1:42-47.

Heroux, J.A., Biggar, K.W. and Brasseur S., 1994. Liquid Waste Management CFS Alert. Proceedings, 7th International Cold Regions Engineering Specialty Conference, Edmonton, Alberta, D.W. Smith and D.C. Segó (eds), pp. 515-522.

Biggar, K.W. and Hoang, P. 1994. The compilation of geotechnical information from the short range radar sites into a public domain database. Proceedings, 7th International Cold Regions Engineering Specialty Conference, Edmonton, Alberta, D.W. Smith and D.C. Segó (eds), pp. 647-656.

Biggar, K.W. and Segó, D.C. 1990. Curing and strength characteristics of cold setting Ciment Fondu grout. Proceedings of the 5th Canadian Permafrost Conference, Quebec city, Quebec.

### **Mine Wastes**

Beier, N. Segó, D.C., Donahue, R. and Biggar, K. 2007. Laboratory investigation on freeze separation of saline mine waste water. *Cold Regions Science and Technology*, 48 (239-247).

Klassen, R., Arenson, L.U., Segó, D.C., Biggar, K.W. 2007. Heat Convection Modeling in Waste Rock Piles. Proceedings, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, Edmonton, AB. May 4-6. pp.247-255.

Abraha, D.G., Segó, D.C., Biggar K.W. and Donahue, R. 2007. Sulfur Concrete for Haul Road Construction at Suncor Oil Sands Mines, *Canadian Geotechnical Journal*, 44:(564-578).

Biggar, K.W., Donahue, R., Segó, D.C., Johnson, M., and Birch, S. 2004. Spray Freezing Decontamination of Tailings Water at the Colomac Mine. *Cold Regions Science and Technology*, 24:106-119.

Silva, M.J., Naeth, M.A. Biggar, K.W., Chanasyk, D.S. and Segó, D.C. 2002. Plant response on oil sand tailings. *Mine Wastes 2002*, Fort Collins, Colorado. pp. 263-270.

Godwaldt, R.C., Biggar, K.W., Segó, D.C., and Foght, J. 2000. AMD generation at sub-zero temperatures. *Proceedings, Environmental Issues and Management of Wastes in Energy and Mineral Production*. Calgary, Alberta, Canada. Singhal & Mehrotra (eds) Balkema., pp. 557 – 563.

Silva, M.J., Biggar, K.W., Segó, D.C., Chanasyk, D.S. and Naeth, M.A. A model for the prediction of bearing capacity on vegetated tailings. *Canadian Geotechnical Journal*. (Accepted July 2000)

Silva, M.J., Biggar, K.W., Segó, D.C., Chanasyk, D.S. and Naeth, M.A. Plant dewatering of tailings: experimental results and model predictions. *Canadian Geotechnical Journal*. (Accepted July 2000)

Silva, M.J., Biggar, K.W., Segó, D.C., Chanasyk, D.S. and Naeth, M.A. Prediction of bearing capacity of vegetated composite tailings. Submitted to the *Canadian Geotechnical Journal*.

Tang, J., Biggar, K.W., Scott, J.D. and Segó, D.C. 1997. Examination of mature fine tailings using scanning electron microscope. *Canadian Geotechnical Conference*, Ottawa 20-23 Oct. pp 746 - 754.

#### **Contaminated Site Assessment and Remediation**

Iwakun1, O., Biggar, K.W., Armstrong, J.E., Donahue, R., and Segó, D.C. Impacts of Oxygenated Infill Water on Dialysis Sampler. Under review, *Groundwater Monitoring and Remediation*.

Alostaz, M., Donahue, R., Segó, D.C., and Biggar, K.W. Principles and Application of Ultraviolet Induced Fluorescence in Detecting Petroleum Hydrocarbon Contamination. Under review, *Environmental Reviews*.

Alostaz et al. Soil Type Effects on Petroleum Contamination Characterization Using Ultra Violet Induced Fluorescence Emission-Excitation Matrices (EEMs) and Parallel Factor Analysis (PARAFAC). Under review, *Journal of Environmental Engineering and Science*.

Alostaz , M., Biggar, K.W., Donahue, R.D., and Hall, G.H. 2008. Petroleum Contamination Characterization and Quantification Using Fluorescence Emission-Excitation Matrices (EEMs) and Parallel Factor Analysis (PARAFAC). Accepted *Journal of Environmental Engineering and Science*.

Ulrich, A., Guigard, S.E., Foght J.M., Semple, K., Pooley, K., Armstrong, J.E., and Biggar, K.W. 2008. Effect of salt on aerobic biodegradation of petroleum hydrocarbons in contaminated groundwater. Accepted, *Biodegradation*, March.

Iwakun, O., Donahue, R., Segó, D., Armstrong, J.E., and Biggar, K.W. 2008. Evaluation of Dialysis Sampler's Integrity. Accepted: *Groundwater Monitoring and Remediation*.

Iwakun, O., Biggar, K.W., Van Stempvoort, D., Bickerton, G., and Voralek, J. 2007. Fuel contamination characterization in permafrost fractured bedrock, at the Colomac mine site. *Cold Regions Science and Technology*, doi:10.1016/j.coldregions.2007.10.001

Van Stempvoort, D., and Biggar, K.W. 2007. Potential for bioremediation of petroleum hydrocarbons in groundwater under cold climate conditions: A review. *Cold Regions Science and Technology*, doi:10.1016/j.coldregions.2007.06.009

Beier, N., Segó, D., Donahue, R., and Biggar, K. 2007. Trickle-freeze separation of contaminants from saline waste water. *International Journal of Mining, Reclamation and Environment*, **21:2**,(144-156).

Beier, N. Segó, D.C., Donahue, R. and Biggar, K. 2007. Laboratory investigation on freeze separation of saline mine waste water. *Cold Regions Science and Technology*, 48 (239-247).

Iwakun, O., Biggar, K.W.,2007. Behavior of spilled petroleum hydrocarbon at Colomac mine site, NWT Proceedings, 60th Canadian Geotechnical Conference and 8th Joint CGS/IAH-CNC Groundwater Conference in Ottawa, Canada, October 21-24, pp. 2106-2114.

Van Stempvoort , D.R., Armstrong J.W., and Biggar, K.W. 2007. Groundwater recharge as a mechanism to replenish sulfate for natural attenuation of hydrocarbon Plumes. Proceedings, 60th Canadian Geotechnical Conference and 8th Joint CGS/IAH-CNC Groundwater Conference in Ottawa, Canada, October 21-24, pp. 249-255.

Bickerton, G, Van Stempvoort, D.R., Voralek, J., and Biggar, K.W. 2007 Hydrogeological setting of petroleum contamination at Colomac mine NWT, A permafrost region of the Canadian Shield. Proceedings, 60th Canadian Geotechnical Conference and 8th Joint CGS/IAH-CNC Groundwater Conference in Ottawa, Canada, October 21-24, pp. 333-340.

Alostaz , M., Biggar, K.W., Donahue, R.D., and Hall, G.H. 2007. Petroleum Contamination Quantification from Ultraviolet Induced Fluorescence Using Emission-Excitation Matrices (EEMs) and Parallel Factor Analysis (PARAFAC). Proceedings, 60th Canadian Geotechnical Conference and 8th Joint CGS/IAH-CNC Groundwater Conference in Ottawa, Canada, October 21-24, pp. 1177-1185.

Alostaz , M., Biggar, K.W., Donahue, R.D., and Hall, G.H. 2007. Soil type effects on Petroleum Contamination Characterization Using Fluorescence Emission-Excitation Matrices (EEMs) and Parallel Factor Analysis (PARAFAC). Proceedings, 60th Canadian Geotechnical Conference and 8th Joint CGS/IAH-CNC Groundwater Conference in Ottawa, Canada, October 21-24, pp. 1872-1880.

Iwakun, O., Biggar, K.W., Van Stempvoort, D.R., 2007 Fuel contamination characterization in permafrost fractured bedrock at the Colomac mine site (NWT). Proceedings, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, Edmonton, AB. May 4-6. pp. 143-166.

Semple, K.M., Fan, X., Foght, J, Guigard, G.E., Biggar, K.W. 2007. Detecting anaerobic hydrocarbon biodegradation signature metabolites in a two-year laboratory study of petroleum-contaminated groundwater and sediment. Proceedings, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, Edmonton, AB. May 4-6. pp. 21-25.

Fan, X , Guigard, G.E., Semple, K.M., Foght, J, and Biggar, K.W. 2007. Enhanced Anaerobic Biodegradation of Condensate-Contaminated Groundwater : A Laboratory Mesocosm Study. Proceedings, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, Edmonton, AB. May 4-6. pp. 12-20.

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- Iwakun, O., Biggar, K.W., Van Stempvoort, D., Bickerton, G., and Voralek, J. 2006. Fuel contamination characterization in permafrost fractured bedrock at the Colomac mine site, NWT. Proceedings, 59<sup>th</sup> Canadian Geotechnical Conference, Vancouver, BC. 1-4 October. Paper No. 261, 8p.
- Ulrich, A.C., Biggar, K.W., Armstrong, J.E., Van Stempvoort, D., Tappenden, K., and Rogers, P. 2006. Impact of cold temperatures on biodegradation rates. Proceedings, 59<sup>th</sup> Canadian Geotechnical Conference, Vancouver, BC. 1-4 October. Paper No. 484, Paper No. 261, 8p.
- Fan, X., Guigard, S., Foght, J. Semple, K., and Biggar, K.W. 2006. A mesocosm study of enhanced anaerobic biodegradation of petroleum hydrocarbons in groundwater from a flare pit site. Proceedings, 59<sup>th</sup> Canadian Geotechnical Conference, Vancouver, BC. 1-4 October. 8p.
- Alostaz, M., Biggar, K.W., Donahue, R., and Hall, G. 2006. Using fluorescence emission-excitation matrices (EEMs) and parallel factor analysis (PARAFAC) for characterizing soil petroleum contaminants. Proceedings, 59<sup>th</sup> Canadian Geotechnical Conference, Vancouver, BC. 1-4 October. 8p.
- Ulrich, A.C., Biggar, K.W., Armstrong, J.E., Van Stempvoort, D., Tappenden, K., and Rogers, P. 2006. Impact of cold temperatures on biodegradation rates. Proceedings, 59<sup>th</sup> Canadian Geotechnical Conference, Vancouver, BC. 1-4 October. p. 8.
- Iwakun, O., Biggar, K.W., Van Stempvoort, D., Bickerton, G., and Voralek, J. 2006. Fuel contamination characterization in permafrost fractured bedrock at the Colomac mine site, NWT. Proceedings, 59<sup>th</sup> Canadian Geotechnical Conference, Vancouver, BC. 1-4 October. p. 8.
- Fan, X., Guigard, S., Foght, J. Semple, K., and Biggar, K.W. 2006. A mesocosm study of enhanced anaerobic biodegradation of petroleum hydrocarbons in groundwater from a flare pit site. Proceedings, 59<sup>th</sup> Canadian Geotechnical Conference, Vancouver, BC. 1-4 October. p. 8.
- Alostaz, M., Biggar, K.W., Donahue, R., and Hall, G. 2006. Using fluorescence emission-excitation matrices (EEMs) and parallel factor analysis (PARAFAC) for characterizing soil petroleum contaminants. Proceedings, 59<sup>th</sup> Canadian Geotechnical Conference, Vancouver, BC. 1-4 October. p. 8.
- Armstrong, J.E., Burkholder, M.K., and Biggar, K.W. 2005. Decision Analysis of Expert Input Related to Cost Evaluation of Natural Attenuation. Proceedings, 58<sup>th</sup> Canadian Geotechnical Conference, Saskatoon, SK., 8p.
- Alostaz, M., Biggar, K.W., Robertson, P.K., Segó, D.C., Donahue, R., and Woeller, D., 2005. CPT-UVIF Evaluation of Subsurface Crude Oil Contamination at the Atlantic No. 3 Site. Proceedings, 58<sup>th</sup> Canadian Geotechnical Conference, Saskatoon, SK., 8p.
- Alostaz, M., Biggar, K.W., Robertson, P.K., Segó, D.C., Donahue, R., and Woeller, D., 2005. Ultra-Violet Induced Fluorescence Detection of Hydrocarbon Contamination – Theoretical Background and Advanced Application. Proceedings, 58<sup>th</sup> Canadian Geotechnical Conference, Saskatoon, SK., 8p.
- Iwakun, O., Biggar, K.W., Armstrong, J.E., Donahue, R., and Segó, D.C., 2005. Evaluation of a Diffusion Sampling System for MNA assessment. Proceedings, 58<sup>th</sup> Canadian Geotechnical Conference, Saskatoon, SK., 8p.

- Beier, N., Biggar, K.W., Donahue, R., and Segó, D.C., 2005. Freeze Separation of Contaminants from salt contaminated Water. Proceedings, 58<sup>th</sup> Canadian Geotechnical Conference, Saskatoon, SK., 8p.
- Foght, J., Semple, K., Pooley K., Guigard, S.E., and Biggar, K. 2005 Effect of salt on aerobic biodegradation of petroleum hydrocarbons in contaminate groundwater. Proceedings, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, Edmonton, AB, May 7-10. pp. 259-268.
- Biggar, K., Donahue R., Segó, D.C., Johnson M. Birch, S., Cyre, G.P. 2005. Spray -freezing decontamination of tailings water at the Colomac Mine. Proceedings, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, Edmonton, AB, May 7-10, pp. 277-286.
- Fan, X., Guigard, S.E., Foght, J., Semple, K., Biggar, K.W. 2005. A mesocosm study of enhanced anaerobic degradation of petroleum hydrocarbons in groundwater. Proceedings, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, Edmonton, AB, May 7-10, pp. 301-310.
- Cross, K.S., Biggar, K.W., Semple, K.S., Foght, J., Guigard, S.E., and Armstrong, J.E. 2005. Intrinsic Bioremediation of Diesel-Contaminated Cold Groundwater in Bedrock. Accepted, Journal of Environmental Engineering and Science May 2005
- Armstrong, J.E., Biggar, K.W., Morin, D., and McLeish, K. 2004. Sampling-method-induced variability and its influence on interpretation of natural attenuation of hydrocarbons. Proceedings, 57<sup>th</sup> Canadian Geotechnical Conference, 5<sup>th</sup> Joint IAH-CNC/CGS Conference, Quebec City, PQ, 24-27 October. p.6.
- Burkholder, M.K., Armstrong, J.E., and Biggar, K.W. 2004. Case study using the decision analysis process to select a remediation strategy for an upstream oil and gas facility. Proceedings, Remediation Technologies Symposium (RemTech), Banff, AB, October 13-15. p.10.
- Armstrong, J.E., Burkholder, M.K., and Biggar, K.W. 2004. Applying decision analysis to site remediation. Paper 2004-137. Proceedings, Petroleum Society's 5<sup>th</sup> Canadian International Petroleum Conference, Calgary, AB, June 8-10. p.7.
- Biggar, K.W., Donahue, R., Segó, D.C., Johnson, M., and Birch, S. 2004. Spray Freezing Decontamination of Tailings Water at the Colomac Mine. Cold Regions Science and Technology, 42:109-116.
- Cross, K.M., Biggar, K.W., Semple, K., Foght, J. Guigard, S.E., and Armstrong, J.E. 2003. Biodegradation of Weathered Diesel Fuel in Groundwater in Anaerobic and Aerobic Microcosms to Assess Natural Attenuation of Total Extractable Hydrocarbon Range Petroleum Hydrocarbons. Proceedings: National Groundwater Association 2003 Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Remediation, August 20-22, 2003. Costa Mesa, California: pp. 295-309.
- Biggar, K.W., D. Woeller, , S. Murphy and J.E. Armstrong, 2003. UVIF-CPT characterization at upstream oil and gas facilities. Proceedings, Vancouver Geotechnical Society annual symposium, Geotechnical Engineering for Geoenvironmental Applications, 22 May, 2003, Vancouver, BC. pp. 31-37.
- Cross, K., K.W. Biggar, K. Semple, J. Foght, S. Guigard and J.E. Armstrong, 2003. Intrinsic bioremediation of invert diesel fuel contaminating groundwater in a bedrock formation, Proceedings of 2003 Third Biennial Workshop on Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, May 5-6, 2003, Edmonton, Alberta. pp. 227-242.
- J.E. Armstrong, C. Deutsch and K.W. Biggar, 2003. Geostatistical assessment of cone penetrometer test data for soil characterization based on ultraviolet induced fluorescence, Proceedings of 56<sup>th</sup> Canadian Geotechnical Conference, 4<sup>th</sup> Joint IAH-CNC/CGS Conference, September 29 - October 1, 2003.

- Van Stempvoort, D.R., J.E. Armstrong and K.W. Biggar, 2002. Significance of Sulfate Reduction in Bioremediation of Hydrocarbons in Groundwater. Proceedings of 55th Canadian Geotechnical and 3rd Joint IAH-CNC/CGS Conference, "Ground and Water: Theory to Practice," Niagara Falls, ON, October 21-24. pp. 885-892.
- Epp., T., J.E. Armstrong and K.W. Biggar, 2002. Guideline Development for Use of Monitored Natural Attenuation at Contaminated Sites in Alberta. Proceedings of: European Conference on Natural Attenuation, October 15-17, 2002, Heidelberg, Germany, pp. 64-67.
- Cross, K.C., Armstrong, J.E., and Biggar, K.W., 2001. Characterization of monitored natural attenuation at upstream oil and gas sites in western Canada. Proceedings, 54<sup>th</sup> Canadian Geotechnical Conference, Calgary, AB, 17-19 Sept, pp.630-638
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- Lai, V., Biggar, K.W., Foght, J., Guigard, S., and Mendoza, C. 2001. Evaluation of intrinsic bioremediation of BTEX and chlorinated solvents at an old landfill in Cold Lake Alberta. Proceedings, 54<sup>th</sup> Canadian Geotechnical Conference, Calgary, AB, 17-19 Sept, pp. 1202-1209.
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- Foght, J., T. April, K. Biggar and J. Aislable. 2001. Bioremediation of DDT-contaminated soils: A review. *Bioremediation J.* 5:225-246.
- Biggar, K.W., Mullick, A., Guigard, S., Foght, J., and Mendoza, C. 2000. Natural Attenuation of 111 TCA and BTEX at Cold Temperatures. Proceedings, 6<sup>th</sup> Environmental Engineering Sepcialty Conference of the CSCE. 7-10 June, London, Ontario, Canada. Pp. 105 – 112.
- Johns, C.A., Biggar, K.W., Foght, J., and Mullick, A. 1999. Intrinsic bioremediation of BTEX in a cold temperature environment. Proceedings, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates. Edmonton, 3-4 May. pp.111 - 118.
- Mullick, A, Biggar, K.W., Foght, J., and Johns, C.A. 1999. Intrinsic bioremediation of chlorinated hydrocarbons at cold temperatures. Proceedings, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates. Edmonton, 3-4 May. pp. 119 - 130.
- Haidar, S., Biggar, K.W., Bennett, J., and Jarrett, P.M. 1998. Bioremediation of petroleum contaminated soil at CFS Alert: Laboratory scale respirometry experiment. Proceedings, Canadian Geotechnical Conference. Edmonton, AB, 4-7 Oct. pp. 197 - 204.
- Biggar, K.W., Mendoza, C.A., and Foght, J.M. 1998. Investigation for intrinsic bioremediation feasibility at a site in Northern Alberta. Proceedings, Canadian Geotechnical Conference. Edmonton, AB, 4-7 Oct. pp. 779 – 786.
- Biggar, K.W. and Yong, S. 1998. Monitoring well casing material behaviour subject to different groundwater contaminants. Proceedings, International Conference on Site Characterization. April 19-22, Atlanta, Georgia. Pp 677-684.
- Biggar, K.W., Haidar, S, Nahir, M.and Jarrett, P.M. 1998. Site investigation of fuel spill migration into permafrost. *ASCE Journal of Cold Regions Engineering*, Vol 12. No. 2, pp. 84-104.

Biggar, K.W. Demque, D.E., and Heroux, J.A. 1997 Land treatment of diesel contaminated sand. Canadian Geotechnical Journal. Vol 34: 421-431.

Haidar, S, Biggar, K.W. and Jarrett, P.M. 1997. Site investigation of fuel contaminated soils in permafrost at CFS Alert. Proceedings, CSCE/ASCE Environmental Engineering Conference. Edmonton, 23-25 July. pp. 1275 - 1288.

Nahir, M., and Biggar, K.W. 1997. Transport of petroleum hydrocarbons in permafrost soils: A case study of two diesel spills at the Isachsen High Arctic Weather Station, NWT. Proceedings, CSCE/ASCE Environmental Engineering Conference. Edmonton, 23-25 July. pp. 1263 - 1274.

### TECHNICAL ACTIVITIES

- 2007/08 Vice President, Edmonton Geotechnical Society
- 2005 Chair, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, A conference held in Edmonton, AB, 8-10 May 2005
- 2003 Chair, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, A conference held in Edmonton, AB, 4-6 May 2003.
- 2001 Chair, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, A conference held in Edmonton, AB, 7-8 May 2001.
- 2000 Chair, specialty session at the 6<sup>th</sup> Environmental Engineering Specialty Conference (CSCE 2000 Conference), on Natural Attenuation of organic contamination.
- 1999 Chair, Assessment and Remediation of Contaminated Sites in Arctic and Cold Climates, A conference held in Edmonton, AB, 3-4 May 1999.
- 1999-2005 Associate Editor (Geoenvironmental), Canadian Geotechnical Journal
- 1999 Session Organizer, 51<sup>st</sup> Canadian Geotechnical Conference, Contaminated site remediation, Edmonton.
- 1999 Associate Editor, 7<sup>th</sup> International Permafrost Conference, Yellowknife
- 1997-99 Chair, Geo-Environmental Division, Canadian Geotechnical Society.
- 1996-98 Member, executive Edmonton Geotechnical Society
- 1995 Chair: Joint Canada/US, Military/Civilian Workshop on technologies and techniques for hydrocarbon remediation in cold and Arctic climates. June 1995. Royal Military College, Kingston, Ontario.
- 1995 Chair, selection committee for 1995 Roger J Brown Award (CGS).
- 1992 Organizing chairman: 46<sup>th</sup> Canadian Geotechnical Conference specialty session on North Warning System geotechnical engineering.

### THESES SUPERVISED

#### Ph. D.

- 2009 Hosseini Geostatistical modelling of natural attenuation



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2009	Iwakun	Behavior of petroleum contaminants in frozen and freezing soil
2008	Fan	Effects of enhancements and co-contaminants on natural attenuation at upstream oil and gas contaminated sites.
2008	Armstrong	Natural attenuation to remediate contamination at upstream oil and gas facilities.
2007	Alostaz	Improved Ultraviolet Induced Fluorescence Cone Penetration Technology for petroleum contaminated site characterization.
2004	Chang	Installation of horizontally directionally drilled wells for provision of potable water
2001	Clementino	Cone penetration testing with horizontal directional drilling
1999	Silva	Plant dewatering and strengthening of fine mine tailings.

**M.Sc.**

2008	Morin	Evaluation of Site Characterization methodologies for natural attenuation evaluation at upstream oil and gas sites.
2006	Ding	The geochemical behaviour of sulfur encapsulated salt for oilsands waste disposal
2006	Abbas	Rheological behaviour of sulfur-salt mixtures for waste disposal.
2006	Ikawun	Dialysis membrane diffusion sampling systems for natural attenuation sampling at upstream oil and gas sites.
2005	Xia	Frost heave mechanisms in freezing soil
2005	Beier	Trickle discharge freeze-separation to treat salt and ammonium contaminated water.
2004	Dawit	Sulfur concrete haul roads.
2004	Willoughby	Thin layer freezing to treat Hog Barn Wastes
2002	Birch	Flow and filtration into horizontally directionally drilled wells for provision of potable water
2001	Cross	Natural attenuation at upstream oil and gas sites
2001	Otto	Freeze separation of chloride contaminated groundwater (pending)
2001	Lai	Intrinsic bioremediation of chlorinated hydrocarbons at cold temperatures
2000	Godwaldt	Acid mine generation in permafrost regions
2000	Hong	Geotechnical properties of crumbed tire rubber
1999	Johns	Intrinsic bioremediation of BTEX at cold temperatures.

- 1999 Mullick Intrinsic bioremediation of chlorinated hydrocarbons at cold temperatures.
- 1997 Tang Fundamental behaviour of Syncrude Fine Tailings.
- 1995 Martinello Case-based study of critical factors affecting soil vapour extraction efficiency.
- 1995 Thelwell The effects of anaerobic biodegradation on the permeability of porous media. (Jointly supervised with J.A. Heroux).
- 1994 Demque Land treatment testing of diesel contaminated soils using bioremediation. (Jointly supervised with J.A. Heroux).

**M.Eng.**

- 2008 Froese Bioengineering stabilization of a river bank
- 2008 Ayorinde Cold Regions Bioremediation
- 2005 Wilhelm Brownfields: Exploring Geo-environmental Prevention and Restoration
- 2003 Heung Undisturbed sampling of loose unsaturated granular soils on old fill slopes in Hong Kong by insitu ground freezing
- 1999 Campbell Enhanced soil vapour extraction in low permeability soils
- 1999 Cotta Mercury remediation of hydrometric stations feasibility study
- 1999 Wong The potential of waterjet reaming device for use in cold permafrost
- 1998 Bin Visual MODFLOW analysis of horizontal drainage pipes in the Southwest Sand Storage area at Syncrude.
- 1998 Thielmann Groundwater modeling of intrinsic bioremediation at CFB Cold Lake POL compound.
- 1997 Niawchuk Analysis of time to total freeze-back of Lupin mine tailings.
- 1997 Ennis The use of composite soil covers for the prevention of acid mine drainage.
- 1997 Grozic Laboratory measurements of unfrozen water content using time domain reflectometry.
- 1996 McCormick The adsorption of organic contaminants onto soils with an evaluation of the use of peat to remediate contaminated water.
- 1996 Garg Bioremediation of PAH contaminated soil: A literature review.

**B.Eng. (RMC)**

- 1995 Goodman Effects of organic permeants geosynthetic clay liners.
- 1995 Neufeld Hydrocarbon migration in permafrost.
- 1994 Hilton Comparative analysis of grout cured in permafrost.
- 1993 Estey Improvement of electrical grounding in permafrost.
- 1993 Nelles The detection of liquid hydrocarbon contamination in frozen soil.
- 1993 Gelinas Comparative analysis of grout cured in frozen soil.
- 1992 Fontaine La mise a la terre en region polaire.

**COURSES TAUGHT AT U of A**

CivE 680	Graduate Course	Advanced Soil Mechanics
CivE 681	Graduate Course:	Seepage and Drainage
CivE 682	Graduate Course:	Geo-Environmental Engineering
CivE 694	Graduate Course:	Permafrost Engineering
EnvE 434	Undergraduate Course	Environmental Geotechnics (new course)
EnvE 351	Undergraduate Course	Environmental Engineering Materials (new course)
CivE 381	Undergraduate Course	Soil Mechanics
CivE 391	Undergraduate Course	Properties of Construction Materials
CivE 270	Undergraduate Course	Mechanics of Deformable Bodies
EngG 130	Undergraduate Course	Engineering Mechanics

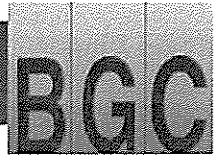
**COURSES TAUGHT AT RMC**

CEE 590	Graduate Course:	Cold Regions Engineering
CEE 317	Undergraduate Course	Civil Engineering Analysis I
CEE 355	Undergraduate Course	Soil Mechanics
CEE 305	Undergraduate Course	Structural Analysis
CEE 303	Undergraduate Course	Strength of Materials
CEE 201	Undergraduate Course	Strength of Materials

**INDUSTRIAL SHORT COURSES TAUGHT**

2007	Permafrost Engineering (U of A)
2006	Environmental Site Assessment (U of A)
2006	Permafrost Engineering (U of A)
2005	Permafrost Engineering (U of A)
2004	Permafrost Engineering (U of A)
2002	Permafrost Engineering (Canmore, AB)
2001	Permafrost Engineering (U of A)
1995	Assessment and Remediation of Contaminated Sites (RMC)
1993	Cold Regions Engineering (RMC)

# RESUME



**K. WAYNE SAVIGNY, Ph.D., P.Eng., P.Geo., P.Geol.**  
*Geological/Geotechnical Engineer and Engineering Geologist*

## **Education:**

B.A.Sc. (Hons.) Geological Engineering,  
1971 Queen's University

Special Student Geology and Civil  
Engineering, 1972/73 University of  
Calgary

Ph.D. Civil (Geotechnical) Engineering,  
1980 University of Alberta

## **Summary of Experience:**

1990 - Co-founder and Principal of BGC  
Engineering Inc.

1995 - Adjunct Professor, University of  
British Columbia

1986 - 1995 Associate Professor,  
Geological Engineering Program,  
Department of Geological Sciences,  
University of British Columbia

1982 - 1986 Principal, Geotechnical  
Engineer and Engineering Geologist,  
Thurber Consult. Ltd.

1978 - 1982 Geotechnical Engineer  
and Engineering Geologist, Thurber  
Consult. Ltd.

1973 - 1978 Graduate Student,  
Department of Civil Engineering,  
University of Alberta

1971 - 1973 Research Associate, Inst.  
Sedimentary and Petroleum Geol.,  
Geol. Surv. of Canada

## **Affiliations:**

Assoc. Prof. Engineers, Geologists and  
Geophysicists of Alberta (P.Eng.,  
P.Geol)

Northwest Territories Assoc. Prof.  
Engineers, Geologists and  
Geophysicists (P.Eng., P.Geol.)

Assoc. Prof. Engineers and  
Geoscientists of British Columbia  
(P.Eng., P.Geol.)

Assoc. Engineering Geologists  
(Member)

Canadian Society of Petroleum  
Geologists (Member)

Canadian Geotechnical Society  
(Member, and Past Chairman -  
Engineering Geology Division)

Geological Assoc. Canada (Fellow and  
Past Director of the Cordilleran Division)

Geological Society of London (Fellow)

Tunnelling Assoc. Canada (Member  
and Past Vice-President for Western  
Canada)

Dr. Savigny has extensive experience in the overlapping fields of Geological/Civil (Geotechnical) Engineering and Engineering Geology, and specializes in the investigation and analysis of geological complexities as they influence engineered development. His experienced has been focused in the following three areas:

- Directing large geotechnical engineering and engineering geology investigations for earth dams, tunnels, thermal power plants, pipelines, mines and industrial complexes in western and Arctic Canada, and several international locations.
- Evaluating natural hazards affecting earth dams and reservoirs, land developments, mines, pipelines, railways, roads, bridges, and transmission lines in North and South America, Europe and Australasia. Dr. Savigny has also developed and implemented methodologies for assessing the exposure of linear facilities to natural hazards, and for managing the attendant risks these hazards pose through unbiased risk-cost-benefit decision analysis techniques.
- Advisor and expert for review panels, inquests, litigations, and public hearings.

Dr. Savigny has received the Thomas Roy and the Roger J.E. Brown Memorial awards from the Canadian Geotechnical Society for outstanding contributions to Engineering Geology and Permafrost in Canada, respectively. He was also selected as the Society's 2005 Cross Canada Lecturer. His consulting work as a member of a DIAVIK review team was recognized with a Public Service Commission of Canada Award of Excellence. He has also received a Teaching Excellence Award from the Faculty of Science at the University of British Columbia.

## **Selected Experience – Permafrost Projects**

- Regional geological mapping on parts of Devon, Cornwall and Cornwallis Island for the Geological Survey of Canada. The mapping, which focused on Mississippi Valley type lead zinc deposits, resulted in staking by several mining companies and development of Polaris mine on Little Cornwallis Island, the most northerly metal mine in the world.

- Surficial geology mapping of the Mackenzie Valley Transportation Corridor (latitudes 60° to 68°) for the Geological Survey of Canada. This became the basis for routing of the Mackenzie Highway and several oil and gas pipeline projects.
- Investigation and analysis of creep movements affecting ice-rich permafrost soils at the proposed Canadian Arctic Gas pipeline crossing of Mackenzie River in Northwest Territories.
- Geotechnical investigation of the Pangnirtung water reservoir failure and site selection of a new location for the facility.
- Engineering geology assessment of reservoir shoreline stability for the Mid Yukon, Granite Canyon, Hoole Canyon, Ross Canyon and False Creek hydroelectric projects in Yukon.
- Development of a reclamation plan for quarries at Norman Wells. The quarries, which had been used for construction of drill platforms in Mackenzie River, were in permafrost comprising both ice-rich clay and rock.
- Terrain analysis of sensitive portions of the Alaska Highway Gas Pipeline from the Alaska-Yukon border to Haines Junction, and through the Ibex Valley near Whitehorse.
- Project Manager for investigation of the tailings dam failures at the Canadian Zinc Corp. Prairie Creek Mine (originally the Cadillac Mine) in southwestern Northwest Territories.
- Project Manager for location and investigation of alternative access road alignments and air strips for the Canadian Zinc Corp. Prairie Creek Mine (originally the Cadillac Mine) in southwestern Northwest Territories.
- Geothermal modeling of heap leach operations at Brewery Creek and Dublin Gulch in Yukon.
- Engineering Project Manager for the bulk sampling of diamondiferous kimberlite pipes at the Lytton Minerals Ltd. Jericho pipe and the Mountain Province Mining Inc. Kennady Lake pipe, both in Northwest Territories.
- Geotechnical audit of the Echo Bay Mines Ltd. Lupin Mine tailings facility, central Northwest Territories.
- Regional study of the interrelationship between seismicity and large landslides in southwestern Yukon and southeastern Alaska.
- Senior geotechnical reviewer for DIAND of the performance of the Enbridge Pipelines (NW) Inc. (Interprovincial) Oil Pipeline from Norman Wells, Northwest Territories, to Zama, Alberta. This is the first buried oil pipeline constructed through permafrost terrain in North America. The work involved studies at more than 50 locations between the Northwest Territories–Alberta border and Mountain River (latitudes 60° and 66°, respectively) spanning the period 1989 to 1996.
- Investigation and back-analysis of the McBride landslide for DIAND. This was a massive piping failure in sub-permafrost sands that impacted the Sans Sault pipeline test facility near the confluence of Mackenzie and Mountain rivers in Northwest Territories.
- Investigation of the Little Doctor Lake landslide for DIAND. This was a 4 million m<sup>3</sup> liquefaction failure in till and colluvium that occurred during the December 1985 North Nahanni earthquake in western Northwest Territories.

- Investigation and back-analysis for DIAND of widespread shallow landslides along the Enbridge Pipelines (NW) Inc. Norman Wells to Zama oil pipeline resulting from the widespread Mackenzie River valley forest fires of 1994.
- Senior geotechnical review for DIAND (through Dillon Consulting Ltd.) of the proposed raising of the Royal Oak Mines Ltd. Colomac Tailings Impoundment, Dams 1 and 2 in Northwest Territories.
- Senior geotechnical review for DIAND Water Resources Division (through Gartner Lee Limited) of the DIAVIK Diamond Mines Inc. Environmental Assessment for its proposed diamond mine at Lac de Gras in Northwest Territories and participation as an expert witness on behalf of DIAND at the 1999 Water Board Hearings in Yellowknife.
- Senior geotechnical review for DIAND Water Resources Division of the DIAVIK Diamond Mines Inc. mine development plans for the A154N&S, A418 and A21 pit developments, preparation of questions related to Water License Applications, and appearance on behalf of DIAND at Mackenzie Land and Water Board Hearings in Yellowknife.
- Senior geotechnical review for the Chief Mine Inspector of Northwest Territories and Nunavut of the Miramar Giant and Con mines at Yellowknife, BHP Diamonds Inc. Ekati Diamond Mine, Canzinc Ltd. Nanisivik Mine, and the Cominco Ltd. Polaris Mine.
- Coupled geothermal and hydrological modeling of pit slope development for the BHP Ekati diamond mine project in Northwest Territories.
- Senior geotechnical reviewer for DIAND of the proposed Ekati Diamond Mine expansion involving the Sable, Pigeon and Beartooth pits, and participation as an expert witness on behalf of DIAND at the 2002 Water Board Hearings in Yellowknife.
- Senior geotechnical review and project manager of 2004-05 geotechnical studies for Placer Dome Ltd. of the Donlin Creek Gold Mining Project in Alaska.
- Senior geotechnical reviewer for Davis and Company (acting for the defendant) in litigation brought against Ekati Diamond Mine regarding alleged siltation of Kodiak Lake as a result of construction of the Panda Pit diversion ditch.
- Senior geotechnical reviewer for Aboriginal Engineering Ltd. regarding closure of quarries in ice-rich clay at Discovery Mine near Yellowknife, Northwest Territories.
- Contract geotechnical research for the Governments of Northwest Territories and Nunavut regarding the state-of-the-art for ice entrapment during terrestrial tailings disposal with applications to permafrost terrain.
- Participation as a member of an international team of experts investigating large-scale instability affecting mountain slopes at Salbertrand in northern Italy, site of the 2006 Winter Olympics. My participation was discerning the several mechanisms that were operative, including the role of degrading permafrost.
- Development and delivery of a course on best practices in mining for DIAND in Yellowknife, Northwest Territories and Iqualuit, Nunavut.
- Development of a best practices manual for DIAND regarding location and construction of pipeline water crossings in permafrost terrain.

- Senior reviewer of permafrost and geotechnical engineering aspects of the Cumberland Resources Ltd. Environmental Assessment for the Meadowbank Gold Project in Nunavut.
- Development of a geohazard database for DIAND of select river and steam crossings along the proposed Mackenzie Gas Project and related gathering pipelines corridor.
- Development of a geohazard and risk assessment methodology for the Department of Fisheries and Oceans Canada of select river and steam crossings along the proposed Mackenzie Gas Project and related gathering pipelines corridor.
- Expert Advisor to NRTEE's codes, standards and related instruments research on climate change adaptation policy, physical infrastructure and the Canadian North.
- Development and delivery of a workshop on best practices in Arctic pipeline location and design for BP PLC.
- Preliminary evaluation and comparison of alternative export pipeline routes from the TNK-BP Kovykta oil and gas field in southeastern Siberia to the Russia-Chinese border. Two routes were considered, one to the north and another to the south of Lake Baykal.
- Regular contributions as an invited lecturer to the Department of Civil and Environmental Engineering, University of Alberta graduate course on permafrost engineering.

### **Selected Technical Publications**

Porter, M., Jakob, M., Savigny, K.W., Fougere, S. and Morgenstern, N. 2007. Risk management for urban flow slides in North Vancouver, Canada. In, Proceedings, 60th Canadian Geotechnical Society Diamond Jubilee Conference and Joint CGS/IAH-CNC Groundwater Conference, held in Ottawa, Canada, 21 to 24 October, 2007, pp. 690-698.

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Pritchard, M., Porter, M., Savigny, K.W., Bruce, I., Keegan, T. and Abbott, B. 2005. CN rockfall hazard risk management system: Experience, enhancements and future direction. In, Proceedings of an International Conference on Landslide Risk Management held in Vancouver, British Columbia, May 31 to June 2, 2005.

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Porter, M., Esford, F. and Savigny, K.W. 2005. Andean pipelines – a challenge for natural hazard and risk managers. In, Proceedings of an International Conference on Terrain and Geohazard Challenges Facing Onshore Oil and Gas Pipelines held in London, U.K., 2 to 4 June 2004 under the sponsorship of the Institution of Civil Engineers. Proceedings published by Thomas Telford Ltd., pp. 259 to 270.

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# RESUME



## **JACK T.C. SETO, M.Sc., P.Eng** *Senior Geotechnical Engineer*

### **Education:**

M.Sc. Universite Laval 1992 Civil Engineering

B.A.Sc. University of Waterloo 1990 Geological Engineering

### **Summary of Experience:**

2007 – present BGC Engineering Inc. Senior Geotechnical Engineer Edmonton, Alberta

1993 – 2007 EBA Engineering Consultants Ltd. Senior Project Engineer (2001 to 2007) Project Engineer (1995 to 1997 and 1998 to 2001) Project Engineer (EIT) (1993-1995) Edmonton, Alberta

1986 – 1989 Research Assistant, Dept. Geological Engineering University of Waterloo, Waterloo, Ontario

1988 Petro Canada Inc. Junior Engineer, Dept. Reservoir Engineering Calgary, Alberta

1987 Syncrude Canada Ltd. Field Technician, Dept. Tailings Engineering Fort McMurray, Alberta

1986-1987 Geological Survey of Canada Research Assistant, Earth Physics Branch Ottawa, Ontario

### **Affiliations:**

*Member Association of Professional Engineers, Geologists and Geophysicists of Alberta (APEGGA)*

*Licensee Association of Professional Engineers, Geologists and Geophysicists of the Northwest Territories and Nunavut (NAPEGG)*

*Licensee Professional Engineers of Ontario (PEO)*

*Licensee Association of Professional Engineers and Geoscientists of British Columbia (APEGBC)*

*Member Canadian Geotechnical Society (CGS)*

*Member Geotechnical Society of Edmonton (GSE)*

Jack Seto is a Senior Geotechnical Engineer with 15 years experience, predominantly in the area of permafrost engineering for a variety of civil, mining and oil and gas development projects throughout the arctic, including the Northwest Territories, Nunavut, Yukon, Alaska and northern Quebec, in addition to Russia and Svalbard, Norway. His expertise is in the design of structures on permafrost, including dams, waste dumps, embankments and buildings. Jack has been involved in several dam remediation projects in permafrost environments. Jack has also participated in numerous geotechnical and geophysical investigations in the north.

The following is a chronological listing of relevant experience to permafrost and geotechnical engineering:

- 2008 East-In-Pit Geotechnical Analysis, Fort McMurray, AB (for Syncrude Canada Ltd.). Project Manager for analyzing geotechnical data, providing direction for geotechnical site investigation and laboratory testing, and carrying out settlement calculations for landform design.
- 2008 High Lake Project, near Kugluktuk, NU (for Zinifex Canada Inc.). Project Manager for geothermal design of tailings facility and waste rock dumps, with consideration to selecting appropriate design air temperatures and climate change scenarios for geothermal modeling.
- 2008 Meadowbank Gold Project Technical Review, near Baker Lake, NU (for Nunavut Water Board). Conducted technical review of dams, dykes, tailings facility and permafrost for water licence application of proposed gold mine project.
- 2008 Sewage Lagoon Project Technical Reviews, Arctic Bay, Clyde River and Cape Dorset, NU (for Nunavut Water Board). Carried out technical review and assessment of the geothermal design of a sewage lagoon for water licence application.
- 2007 Max Molybdenum Project, near Trout Lake, BC (for Roca Mines). Site Engineer supervising foundation preparation and construction of two till core tailings dams.

- 2007-2008 Punta Cachos Feasibility Design of Main Power Station and Associated Facilities (for SNC-Lavalin). Senior Geotechnical Engineer responsible for preparing a factual data report and geotechnical recommendations for a proposed power station, port and dock site, and ash disposal facility.
- 2007 Mackenzie Gas Project, Fort Good Hope Area, NT (for Colt KBR). Geotechnical Field Manager for Site Investigations. Project consisted of collecting geotechnical and geophysical data for borrow and infrastructures. Supervised crew of field engineers responsible for logging boreholes and testpits and collecting soil samples for laboratory testing.
- 2006 Doris North Project, Hope Bay, NU (subconsultant to SRK Consulting). Senior Project Engineer responsible for the thermal design of two tailings dams largely sited on ice-rich, saline permafrost. Thermal, stability, and creep-deformation analyses were carried out.
- 2006 Thermal Evaluation of Waste Rock Piles, EKATI Diamond Mine, NT (for BHP Billiton Diamonds Inc.). A conductive heat-transfer model was modified to consider the thermal impact of convective cooling and to predict its influence on the long-term thermal regime of such waste rock piles for closure and reclamation planning.
- 2004-2007 Colomac Mine, NT (subconsultant to SRK Consulting). Specialist geothermal engineer brought into the project to carry out the thermal design of a new tailings dam. The existing tailings dam was leaking water contaminated with cyanide and metals. After detailed evaluation, it was concluded that the existing dam could not be repaired and a new dam would have to be designed and constructed. The new dam was sited in an area of warm permafrost soils over fractured bedrock, which would be pervious if allowed to thaw. The new dam was designed as a rockfill structure with an internal geomembrane liner system keyed into mineral permafrost soils in the central portion of the dam, and tailings-bentonite along the abutments. Underseepage due to thaw of the permafrost foundation was determined to be the most likely mode of dam failure. The design included thermosyphons to reduce ground temperatures within the foundation soils early in the design life of the structure. The design also included a blanket of coarse rock over the dam crest and downstream slope to enhance provide passive winter cooling through natural convection in the pore space and enhance the longevity of the dam. Also participated as Site Engineer during dam construction in the winter of 2006/2007.
- 2006 Ground Freezing Feasibility Design – Pine Point Mine, NT (for Tamerlane Ventures). Senior Project Engineer responsible for evaluating the technical feasibility of developing a frozen perimeter wall for groundwater control during shaft sinking.
- 2001 to 2006 DEW Line Project – FOX-2, FOX-3, PIN-2 and CAM-1 DEW Line sites across the eastern Arctic, Nunavut (for UMA Engineering Ltd.). Site Geotechnical Engineer evaluating existing landfills and debris areas, proposed landfills, and potential borrow areas. Reviewed magnetometer data and conducted visual site inspections to differentiate between buried and exposed debris. Also conducted thermal analyses landfill design, which relied on permafrost encapsulation of the waste contents for at least 100 years, with consideration to future climate change.
- 2005-2006 School Foundation Rehabilitation, Ross River, YT (for Yukon Government Department of Highways and Public Works). Senior Project Engineer assisting in developing remediation recommendations for thermosyphon-stabilized foundation undergoing thaw-settlement problems. Reviewed construction history, subsurface conditions, and available air and ground temperature data since construction of these facilities. Calibrated thermal model with measured ground temperature data. Used

thermal model to assess thermosyphon performance and evaluate remedial options, including benefits of active refrigeration. Recommended option was to add thermosyphons and insulation around the building perimeter.

- 2005 Diavik Diamond Project, Lac de Gras, NT (for Diavik Diamond Mines Inc.). Senior Project Engineer responsible for evaluating the feasibility of ground freezing as a means of controlling water flow through a pervious fault zone. Parametric thermal analyses were conducted to determine what conditions (freeze pipe configuration, rock mass and groundwater flow conditions) would be required for ground freezing to be viable.
- 2005 Taglu Site Development, Mackenzie Delta, NT (for Colt KBR). Project Manager for geotechnical design of facilities at Imperial Oil's Taglu site. Developed design configuration for embankment pad composed of granular fill, insulation, and ice. Provided pile capacity charts for adfreeze piles. Conducted thermal analyses to evaluate geothermal effects of permanent and temporary flaring on surrounding pad and terrain.
- 2005 Geotechnical Field Manager for the Mackenzie Gas Project, Taglu Development Site, Mackenzie Delta, NT (for Colt KBR). Project consisted of collecting geotechnical and geophysical data for foundation design of the proposed facilities at the Taglu gas field. Worked with Geophysical Field Manager and client's Technical Supervisor to plan locations for boreholes and geophysical survey lines, as well as locations for ground temperature cable installations.
- 2005 Niglintgak Site Development, Mackenzie Gas Project, NT (for Shell Canada Inc.). Provided third-party review of geotechnical design of facilities.
- 2004-2005 Parsons Lake Site Development, Mackenzie Gas Project, NT (for Colt KBR/Conoco Phillips Canada). Senior Project Engineer responsible for developing geotechnical design parameters for the Parsons Lake gas field facilities, including the design of an insulated granular pad and adfreeze pile foundations.
- 2004-2005 Mine Tailings-Waste Rock Mixture Frozen Backfill Investigation, Raglan Mine, northern Quebec. Supervised triaxial compression testing program of a frozen mixture of crushed rockfill blended with mine tailings as part of a study to evaluate if a frozen wall comprised of these materials could support higher wall panels that can be excavated during recovery of the underground ore. Preliminary thermal, stability, and creep-deformation analyses were carried out to determine the freeze pipe configuration required to develop a frozen wall.
- 2004 Mackenzie Gas Project, Gwich'in Settlement Area, NT (for Colt KBR). Geotechnical Field Manager for site investigation activities of prospective borrow areas along the proposed Mackenzie Gas Project pipeline route. Supervised crew of field engineers responsible for logging boreholes and testpits and collecting soil samples for laboratory testing. Based out of a remote field camp, coordinated logistical support for crew with Field Superintendent, planned laboratory test program, and compiled field summary reports for each borrow area.
- 2004 Victor Diamond Project, northern Ontario (for AMEC). Senior Project Engineer providing thermal design of plant site foundations, airstrip and fuel tank farm.
- 2004-2006 Tailings Dyke Stabilization, Kubaka Gold Mine, Russia (for Kinross Inc.). The 50 m high dyke is constructed in a narrow valley over warm permafrost. Recent survey monitoring indicated that the dyke

was steadily moving downslope. As the client wished to continue raising the dyke for future mine production, analyses were carried out to whether or not this was feasible. Conducted FLAC stress-deformation analyses to identify possible mechanisms for the observed movements. Further analyses were carried out to evaluate the risks of raising the dyke and develop alternative methods of raising the dyke without initiating increased dyke movements.

- 2003 Two Rock Dam, EKATI Diamond Mine, NT (for BHP Billiton Diamonds Inc.). Project manager for the design of Two Rock Dam, a low-head, frozen core dam founded on ice-rich permafrost. Thermal, stability, and creep-deformation analyses were carried out as part of dam design.
- 2002 Bearclaw Diversion Dam, EKATI Diamond Mine, NT (for BHP Billiton Diamonds Inc.). Project manager for the design of Bearclaw Diversion Dam, a low-head, frozen core water diversion dam constructed upstream of an open pit. Prepared report and construction specifications, supervised preparation of construction drawings and instrumentation program.
- 2002 Airport Runway Assessment, Yellowknife, NT (for NWT Department of Transportation). Senior Geotechnical Engineer responsible for managing site investigations at Yellowknife Airport to determine the causes of runway settlement. Portions of the runway have experienced a long history of pavement instability. A combined geophysical and geotechnical investigation was carried out to determine subsurface conditions over the airport property. The thaw unstable subgrade soils encountered in previous geotechnical investigations were found to be localized. Recent subgrade settlement was attributed to recent climate warming. Geophysical profiling of the pavement structure showed areas with thick and irregular asphalt cover, indicative of past pavement instability. Thermal analyses were carried out to evaluate remedial options. Recommendations for managing pavement stability were presented.
- 2001-2002 Design and Construction Guidelines for Petroleum Exploration Infrastructure, Mackenzie Delta, NT (for Mackenzie Delta Infrastructure Group). The work was carried out for a consortium of petroleum operators with interests in the Mackenzie Delta region. Duties included an evaluation of the following: embankment design; foundations for exploration drilling equipment; temporary ice drill pads; foundations for long-term facilities, and sumps. Carried out a literature review summarizing the current state of practice for the above areas. Conducted foundation and thermal analyses to support conceptual designs.
- 2001 Planning for Abandonment of Tailings Containment Facility, Lupin Mine, NU (Echo Bay Resources). Senior Project Engineer responsible for evaluating geotechnical considerations for abandonment of the Tailings Containment Area, including identifying data gaps. Reviewed available geotechnical data, including dyke cross sections, ground temperature instrumentation data, and the thermal performance of the tailings cover.
- 2000 Seepage Dyke Remediation, former Mount Nansen Mine Site, YT (for Department of Indian and Northern Affairs Canada, Whitehorse). Project Engineer responsible for the design of the remediation of a leaky seepage dyke. A geomembrane liner keyed to frozen ground was selected as the remedial option. Conducted slope stability and thermal analyses to verify the technical feasibility of the remediation works. Supervised preparation of construction drawings and assisted in the preparation of construction specifications.
- 2000 Garrow Lake Dam Decommissioning, Polaris Mine, NU (for Cominco). Conducted thermal and stability analyses for dam decommissioning.



- 1999 Misery Site Development, EKATI Diamond Mine, NT (for BHP Billiton Diamonds Inc.). Project Engineer responsible for the thermal design of two lined rockfill dams keyed into permafrost foundation.
- 1999 Spillway Dam Design, EKATI Diamond Mine, NT (for BHP Billiton Diamonds Inc.). Project Engineer responsible for conducting FLAC creep deformation analysis for the design of a frozen core dam founded on ice-rich lacustrine soils.
- 1998-1999 Waste Rock Storage Pad Design, Pogo Mine, Alaska (for Teck Corporation). Conducted thermal analysis for the design of a waste rock storage pad constructed over warm permafrost foundation. The storage pad was lined with a geomembrane liner. Supervised preparation of construction drawings and specifications.
- 1997 Baley Gold Project, Russia (for Cyprus-AMAX Minerals). Project Engineer supervising rock core triaxial and uniaxial compression testing program, Hydroproject Institute, Moscow, Russia. Ensured testing was carried out to ASTM standards.
- 1996 Tailings Deposition Planning, Kubaka Mine, Russia (for AMAX). Project Engineer responsible for conducting thermal analyses for optimizing tailings placement that promotes full freezeback of the tailings to enhance tailings stability.
- 1996 Dam remediation, Raglan Mine, northern Quebec (Bechtel/Falconbridge). The frozen core water retention dam exhibited seepage downstream of the dam toe shortly after initial impoundment. Acted as site engineer identifying the causes and effects of seepage, collecting and evaluating ground temperature data and supervising a coring program through the dam embankment to assess the state of the frozen core.
- 1995 Water Retention Dam Design, Kubaka Mine, Russia (for AMAX). Project Engineer responsible for conducting thermal analysis for the design of a water retention dam.
- 1995 Site engineer, borrow source investigation, Diavik Diamond Project, NT (for Kennecott). Logged geotechnical boreholes and collected soil samples for further laboratory testing.
- 1995 Water Retention Dam, Minto Mine, YT (for Minto Explorations Ltd.). Project Engineer responsible for carrying out thermal design of water retention dam.
- 1994-1995 Tailings Dam Design, EKATI Diamond Mine, NT (for BHP Billiton Diamonds Inc.). Project Engineer conducting thermal analyses for the design of frozen core dams,
- 1994 Refugio Gold Mine, Chile (for AMAX Minerals). Project Engineer responsible for evaluating the effects of cold climatic conditions on heap leaching operations. Conducted laboratory thermal conductivity tests on mine leach ore and used the data in a thermal model to determine if the heap leach operation could be effective in the high alpine environment.
- 1992 Frost Heave Tests (for Northern Engineering, Alaska). Conducted laboratory frost heave tests of Coldfoot silt to characterize frost susceptibility of foundation material for pipeline design.
- 1987 Mildred Lake Settling Basin, Syncrude Canada Ltd., Fort McMurray, AB. Field technician responsible for monitoring piezometer and slope inclinometer measurements around the Mildred Lake tailings pond.

**Technical Publications**

Performance of Two Rockfill Dams with Thermosyphons on Permafrost Foundations, EKATI Diamond Mine, NT, with D.W. Hayley, C.K. Gräpel, D.C. Cathro, and M.A. Valeriote. Proceedings of the 57th Canadian Geotechnical Conference, Quebec City, Quebec, October 2004, Session 5F, pp. 32-39.

Investigation and Assessment of Runways Overlying Warm Permafrost, Yellowknife Airport, with D.W. Hayley, N.S. Parry, and L. Trudel. Proceedings of the Cold Regions Engineering and Construction Conference, Edmonton, AB, May 2004.

Permafrost Response Following Reconstruction of the Yellowknife Highway, with T.E. Hoeve and D.W. Hayley. Proceedings of the Cold Regions Engineering and Construction Conference, Edmonton, AB, May 2004.

Pore Pressure Measurements During the Freezing of an Overconsolidated Clayey Silt, with J.M. Konrad. Cold Regions Science and Technology, Vol. 22, pp. 319-338, 1994.

Frost Heave Characteristics of Undisturbed Sensitive Champlain Sea Clay, with J.M. Konrad. Canadian Geotechnical Journal, Vol. 31, pp. 285-298, 1994.

Freezing Tests with Applied Backpressure, with J.M. Konrad. Frost and Ice Formation Session, Winter Annual ASTM Meeting, Anaheim, California, November 1992.

Freezing of a Clayey Silt Contaminated with an Organic Solvent, with J.M. Konrad. Journal of Contaminant Hydrology, 8, pp. 335-355, 1991.