Mississauga

Education

B.Sc. Civil Engineering, University of Saskatchewan, 1974

M.Sc. Geotechnical Engineering, University of Saskatchewan, 1977

Languages

English – Fluent

Principal

Mr. Bocking is a Principal in Golder Associates' Mississauga Office. He holds an M.Sc. degree in geotechnical engineering and has over 45 years of experience in geotechnical consulting, much of it for mining sector clients. In the past 32 years he has been involved almost exclusively on mine waste management projects at locations around the world. He has been responsible for the siting, permitting, design, construction inspection and closure planning for numerous tailings basins and other mine waste facilities. His projects typically involve aspects of regulatory approvals and environmental compliance.

Employment History

Golder Associates Ltd. – Mississauga, Ontario
Principal (2010 to Present)

Principal in the multi-disciplinary Mine Waste & Environment Division. Involved in the planning, permitting, design and closure of numerous mine waste facilities around the world. Responsible for project management, geotechnical / environmental engineering and costing for mine waste and mine water management components as part of pre-feasibility and feasibility studies or detailed design. Projects often focus on prediction and mitigation of environmental impacts, including: geochemical characterisation of mine wastes, consideration of alternative strategies to manage mine wastes to minimize acid generation, mine water management, mine closure planning, etc. Senior Reviewer for numerous mine closure plans around the world. Also conducts inspections, reviews and audits of mine waste facilities.

Golder Associates Pty Ltd – Brisbane
Principal (2007 to 2009)

Responsible for project management and geotechnical/environmental engineering on mine waste projects in Australasia and Asia, involving the siting, planning, permitting, design and closure of mine waste facilities. Responsible for geotechnical site inspections during the construction of the residue storage facility at the Goro Nickel Project. Project Manager for mine waste and mine water management aspects for pre-feasibility and feasibility studies for a gold mine in Laos.

Golder Associates Ltd. – Mississauga, Ontario
Associate, then Principal, Group Manager (1988 to 2006)

Manager of the Mine Waste & Environment Group (1999 - 2006). Involved in the planning, permitting, design and closure of numerous mine waste facilities. Responsible for project management and geotechnical engineering for tailings, waste rock and mine water management facilities for gold, uranium and base metal mines. Projects typically involved: facility siting, feasibility studies, permitting, tailings deposition planning, geotechnical investigations, construction materials assessment, design of dams and appurtenances, preparation of

drawings and specifications, instrumentation and monitoring, and construction supervision. Projects often focused on environmental aspects, including: geochemical characterization, minimization of acid runoff from tailings or waste rock, mine water management, preparation of mine closure plans, assessment and mitigation of groundwater impacts, reclamation of mine sites, etc.

Golder Associates Ltd. – Saskatoon, Saskatchewan
Senior Geotechnical Engineer, then Associate (1984 to 1988)

Manager of Saskatoon office 1985 to 1986. Responsible for management and technical supervision of numerous geotechnical investigations and construction inspection projects involving: building foundations, mining infrastructure, highways, runways, water storage dams and sewage lagoons. Carried out numerous geotechnical pre-design or surfacing studies for highway projects requiring air photo interpretation, terrain evaluation, granular resource assessment and cost comparisons. Supervised slope stability investigations.

Thurber Consultants Ltd. – Victoria, B.C.
Project Engineer (1978 to 1984)

Conducted geotechnical investigations, prepared reports and supervised construction inspection on a wide variety of projects throughout British Columbia. Assignments included: foundation studies for several railway bridges; slope stability and settlement analysis of high railway cuts and fills, pavement design for a log sort yard, inspection of construction of water supply dams, assessment of gravel resources, review of shear strength testing on shale from B.C. Hydro's Site C Dam, and supervision of a lab program testing core-filter compatibility for Revelstoke Dam.

Ground Engineering Ltd. – Regina & Saskatoon, Saskatchewan
Geotechnical Engineer (1976 to 1978)

Carried out numerous geotechnical studies throughout southern Saskatchewan. Assignments included: field supervision of drilling, installation of geotechnical instrumentation, preparation of foundation reports, and inspection of construction of a variety of pile and caisson foundations. Worked on a large open pit test excavation for the Coronach thermal coal project.

PROJECT EXPERIENCE – DAM ENGINEERING

West Morgan Lake Dam Onaping, ON, Canada	Responsible for the design and construction inspection for a dam to isolate a tailings area from an adjacent freshwater lake. To achieve very low seepage, a deep cut-off and pressure grouting of bedrock was required.
Kwe West Residue Storage Facility New Caledonia	In 2008-2009, acted as Design Engineer during the partial construction of a large dam (66m maximum design height) on complex residual soils. Carried out monthly site visits and construction review meetings and was responsible for approval of changes to design on specifications.
Caribou Mine New Brunswick, Canada	Carried out an initial inspection of two dams. Designed and inspected construction of remedial measures to improve dam performance. Completed annual dam safety inspections for several years.
Dam Safety Inspections North-eastern Ontario, Canada	From 1990 to present, annual dam safety inspections for up to 7 mining properties, including 3 tailings areas and 4 mine water ponds. Reports meet requirements for regulatory approval.
Holloway - Holt Tailings Management Area Kirkland Lake, ON, Canada	From 1995 to present, Engineer-of-Record for a TMA that includes 18 dams and 5 spillways. Responsible for detailed design and oversight of construction for numerous episodes of construction of dams, spillways and other water management facilities. Responsible for annual dam safety inspections.
Essakane Mine Burkina Faso	From 2013 to 2017, Engineer-of-Record for a Tailings Storage Facility and water management facilities. Responsible for annual dam safety inspections. Member of the tailings steering committee. Project Director for updating of the mine closure plan.

PROJECT EXPERIENCE – MINE WASTE MANAGEMENT IN PERMAFROST SETTINGS

NICO Project Northwest Territories, Canada	Conceptual and feasibility design and permitting of a facility for the co-disposal of mine rock and thickened tailings in discontinuous permafrost.
Lupin Gold Mine Nunavut, Canada	Preparation of a Final Closure and Reclamation Plan for an inactive mine, which is being closed out. Regulatory support, environmental site assessment, Human Health and Environmental Risk Assessment, detailed design for closure of waste rock "dome", and closure cost estimating.
Kumtor Gold Mine Siberia, Russia	Detailed design of a filter tailings deposition "stack" in continuous permafrost. Preparation of a comprehensive site-wide water balance. Subject matter expert in risk assessment sessions.
Kumtor Gold Mine Siberia, Russia	Detailed design of a filter tailings deposition "stack" in continuous permafrost. Preparation of a comprehensive site-wide water balance. Subject matter expert in risk assessment sessions.

Kubaka Gold Mine Siberia, Russia	Tailings deposition planning and feasibility level design of a proposed frozen core tailings dam.
Tundra Mine Northwest Territories, Canada	Specialist review of closure planning for an abandoned acid generating tailings facility in continuous permafrost. Technical direction of preliminary design of closure measures.
Nanisivik Mine Baffin Island, Nunavut, Canada	Responsible for hydrology and water management for closure planning for an acid generating base metal mine. Detailed design of a permanent spillway, permanent pond erosion protection and water conveyance facilities for permanent closure.
Raglan Feasibility Study Quebec, Canada	Involved in the geotechnical investigation and reporting for the feasibility study for Glencore's Raglan Mine.
Kiggavik Project Nunavut Territory, Canada	Project Manager for the comprehensive investigations for a proposed uranium mine near Baker Lake. This involved a complete feasibility level geotechnical investigation for all aspects of the proposed mine, including the: open pits, mill foundations, tailings facilities, camp, water intake, borrow areas, landing strip, barge dock, etc. It also involved the conceptual design and detailed thermal modelling of two tailings facilities designed to freeze-back.
Nunavik Project Quebec, Canada	Technical review of disposal concepts and plans for waste rock and pyrrhotite tailings and of the mill foundation design.
Veduga Project Siberia, Russia	Siting and pre-feasibility level design of a tailings facility in discontinuous permafrost.

PROJECT EXPERIENCE – MANAGEMENT OF ACID MINE DRAINAGE

New Tailings Area Sudbury, Ontario, Canada	Feasibility assessment, optimization, detailed design and construction supervision for the flooding of Glencore's New Tailings Area to mitigate future acid generation. The project involved: hydrologic assessment of runoff available to maintain flooding, hydrotechnical design of spillways, groundwater modelling to estimate seepage losses, detailed design of 3 new earth dams and spillway facilities, preparation of plans and specs, and construction quality control.
Los Frailes Mine Aznalcollar, Spain	Senior level participation on the team which planned and designed remedial measures for the stabilization and closure of the failed tailings impoundment at Boliden Apirsa's mill in Aznalcollar, Spain. Remedial measures included: dam lowering and berm construction, regrading to redirect drainage away from the failure, construction of a very large O2 barrier cover over pyritic tailings, and measures to contain and intercept contaminated groundwater.
Cigar Lake Uranium Mine Northern Saskatchewan, Canada	Siting, conceptual design and preparation of permitting support documents for a mine rock disposal facility for the Cigar Lake Uranium Mine in Saskatchewan. The project involved detailed consideration of the potential deposition of mine rock directly into one of two lakes to preclude acid generation. Detailed costing was also undertaken for hauling the mine rock to disposal in a remote open pit.

Mattagami Lake Mine Mattagami, Quebec, Canada	Multidisciplinary study for disposal of acid generating mill tailings in exhausted underground and surface workings at Noranda Minerals' Mattagami Lake Mine. The study included preparation of two permitting documents for submission to Quebec Environment.
Owl Creek Mine Timmins, Ontario, Canada	Conceptual design, costing and evaluation of various options for remediation of a severe acid generation problem involving waste rock from an open pit gold mine near Timmins, Ontario. The waste rock was moved into the open pit and flooded with concurrent lime addition.
Bouchard Hebert Mine Rouyn - Noranda, Quebec, Canada	Planning, investigation, design, permitting and construction inspection for a tailings basin for Bouchard-Hebert Mine). The facility, which includes 7 dams up to 18 m high on soft clay foundations, was originally designed to be flooded upon closure to prevent acid generation by the sulphidic tailings.
Caribou Mine Bathurst, New Brunswick, Canada	Planning, design and construction inspection of dam raises to allow flooding of existing sulphide tailings at Caribou Mine, New Brunswick. Conceptual planning of subaqueous tailings deposition to support an upstream dam raise.
Kidd Metallurgical Site Timmins, Ontario, Canada	Lead or participated in various studies of costs and alternatives for conventional lime treatment of acidic runoff from an 11km2 tailings area in perpetuity after closure. Alternatives considered included: High density sludge treatment, application of a cover of inert tailings, ending co-disposal of jarosite, destruction of thiosalts, adding live storage to treatment ponds, etc. Managed studies to assess the trade-off between closure cover efficiency and cost against long term post-closure water treatment.

PROJECT EXPERIENCE – MINE CLOSURE PLANNING

Kidd Metallurgical Site Timmins, Ontario, Canada	Preparation of two closure plans for Glencore's Kidd Metallurgical Site near Timmins, Ontario in 2001. One involved closure of the large metallurgical complex itself; the other involved the closure of the Tailings Management Area. With a gross area of over 11 km2, the TMA comprises one of the world's largest thickened tailings cones, together with areas for slag disposal, for sludge disposal and for treatment of acidic water. Completed an extensive update of the TMA Closure Plan in 2011-2013.
Kidd Metallurgical Site Timmins, Ontario, Canada	Extensive updating of the TMA Closure Plan in 2012. Background studies included hydrogeologic investigation and modelling as well as extensive soil cover modelling and design. The cost estimate for closure was detailed and updated following stage gate procedures.

Glencore Nickel Smelter Sudbury, Ontario, Canada	Preparation and more recently updating of a closure plan for Glencore Smelter complex near Sudbury, Ontario, which includes: two mines, 5 historic tailings areas, large slag deposits, extensive water management facilities, and the smelter complex itself. The project involved two years of studies involving: geochemical characterisation of a variety of wastes, assessment of groundwater impacts and remediation, seismic stability assessments, biological studies, hydrology, crown pillar stability evaluations, etc. This was followed by conceptual planning and costing of closure measures, and prediction of loadings and impacts.
New Tailings Area Sudbury, Ontario, Canada	Preparation and more recently updating of a closure plan for Glencore's New Tailings Area near the Sudbury, Ontario Smelter. This included geochemical characterization on tailings and prediction of impacts of flooding on the quality of surface water and groundwater.
Fault Lake Tailings Area Sudbury, Ontario, Canada	Preparation of a closure plan for Glencore's Fault Lake Tailings Area. Closure measures included the construction of a multi-element soil cover to reduce the rate of oxidation of existing sulphidic tailings and to mitigate impacts on regional groundwater.
Fecunis Tailings Area Onaping, Ontario, Canada	Study of options for closure of Glencore's Fecunis Tailings Area, considering the feasibility of: flooding, slimes cover, removal of tailings and perpetual treatment. A geotechnical/geochemical investigation lead to a detailed assessment of capital and operating costs for the various options.
NICO Project Northwest Territories, Canada	Preparation of a Conceptual Closure and Reclamation Plan (CCRP) for a proposed gold-cobalt-bismuth-copper mine. This was in support of permitting and licensure of the mine and included a detailed cost estimate for financial assurance.
Hammond Reef Project Atikokan, Ontario, Canada	Conceptual planning (for EIS) of closure measures for a proposed large tonnage gold mine. Preparation of a formal detailed closure plan for permitting purposes.
Holloway Complex Matheson, Ontario, Canada	Preparation of a comprehensive closure plan for three neighbouring underground gold mines, a mill complex and a tailings management facility. This involved detailed tailings deposition planning so that arseno-pyrite tailings would be submerged at closure. More recently, studies were completed in support of an amendment using subaerial tailings stacking.
Bicroft Tailings Area Bancroft, Ontario, Canada	Design, costing and construction supervision of an engineered decommissioning of the inactive uranium tailings basins at Bicroft Uranium Mine. The project involved remedial work and seismic stability upgrading of 4 existing tailings dams, construction of a new dam, and construction of several spillways.
Closure Plans for Stock, Clavos, Taylor and Hislop Mines Timmins, Ontario, Canada	Completion and subsequent updating of a mine closure plan for St. Andrew Goldfields Stock Mine, near Timmins, including detailed planning of tailings deposition and water management. Also, closure plans for satellite mines at: Clavos, Taylor and Hislop which focussed on water management and waste rock management.

Shakespeare Mine Agnew Lake, Ontario, Canada	Lead the preparation and approval of a multi-stage closure plan for a base metal mine mill, water management system and co-disposal area for tailings and waste rock, including cost estimates.
Cerro Colorado Mine near Iquique, Chile	Technical advisor and reviewer for a closure plan for a large copper mine and heap leaching facility in a desert environment. Risk assessment was used to prioritise issues and identify preferred closure alternatives.
Alto Chicama Mine Andes Mountains, Peru	Technical Advisor and reviewer for a closure plan for a large open pit gold mine in the high Andes. The mine uses cyanide heap leaching.
Coldstream Mine Burchell Lake, Ontario, Canada	Detailed design and construction supervision of tailings relocation, water management channels and a soil covered tailings relocation area.
Eastmaque Mine Closure Kirkland Lake, Ontario, Canada	Completion of a mine closure plan for the Eastmaque tailings remilling project in Kirkland Lake. The project involved detailed design of several channels, spillways and control structures, dam remediation, etc.

PROJECT EXPERIENCE – SITING AND PLANNING OF MINE WASTE FACILITIES

NICO Project Northwest Territories, Canada	Siting and consideration of alternative methods for disposal of tailings and mine rock. Feasibility level design of a co-disposal facility (CDF) for tailings and mine rock. Water management planning and preparation of mine closure plans. Assistance with permitting and licensure of the CDF.
Lac Bloom Mine Fermont, Quebec, Canada	High level audit of tailings management practices at a large tonnage iron mine. Evaluation of options for the development of a new tailings area. Brainstorming and evaluation of options for increasing tailings capacity in the long term.
Kiggavik Uranium Project Baker Lake, Northwest Territories, Canada	Complete geotechnical and siting studies for all infrastructure for the proposed Kiggavik Uranium Mine, Northwest Territories., including participation in the siting, design and thermal modelling of a unique mine rock and tailings disposal facility in permafrost.
Los Frailes Mine Aznalcollar, Spain	Study of potential surface disposal sites for tailings from the restart of Boliden Apirsa's Los Frailes Mine in Aznalcollar, Spain. Both slurry and "dry" tailings disposal concepts were considered in an area of highly seasonal rainfall.
Cigar Lake Uranium Mine Northern Saskatchewan, Canada	Evaluation of potential sites and disposal concepts for tailings and mine rock for the world's highest grade uranium mine at Cigar Lake. A wide range of options were considered, and several conceptual designs were completed in preparation for environmental hearings.
Rambler Project Baie Verte, Newfoundland, Canada	Screening of sites and disposal concepts for a proposed mining/tailings remilling scheme in Baie Verte, Newfoundland, including consideration of depositing tailings in existing flooded underground workings.

Estrades Project Casa Berardi Area, Quebec, Canada	Geotechnical investigations for a feasibility study for Breakwater Resources' Estrades Mine, including surficial geology interpretation, and seismic mapping of overburden depth. Provided recommendations for siting and design of mill, ramp, crown pillar excavation, tailings facility, shaft, etc.

PROJECT EXPERIENCE – MINE WATER MANAGEMENT

Sigma Mine Val d'Or Quebec, Canada	Operational audit of an existing gold mine in Quebec. Water balance analysis resulted in identification of major seepage losses out of a tailings area. It also resulted in an implementation of recirculation to reduce discharges and save on costs of raw water.
Stock Mine Timmins, Ontario, Canada	Detailed property wide water balance which demonstrated that it was not possible to comply with existing terms of the C of A. The report supported an application for a reduced receiver dilution factor and an extended discharge period.
Kubaka Mine Siberia, Russia	Detailed multi-year water balance for a proposed gold mine tailings basin in Siberia. The objectives included: zero discharge (under average annual precipitation) and minimizing pond storage to prevent thermal disturbance of permafrost.
Holt - McDermott Mine Matheson, Ontario, Canada	Development of revised tailings basin water management plans for a gold mine in Northern Ontario to maintain 1-year storage/batch discharge operation in order to maximize breakdown of ammonia. As a first step, a new dam and associated water transfer pipelines were constructed to create a three-pond water storage system. As a second step, a fourth pond was designed and constructed, and post closure flooding was implemented to control acid generation. The project has involved detailed hydrologic analysis (i.e. flood routing, stochastic drought analysis, pipeline flow modelling, etc.) as well as the detailed design and construction of four dams and two spillways.
Clavos Mine Timmins, Ontario, Canada	Operational design, geotechnical design and complete permitting services for a sedimentation pond for an advanced exploration project. Analysis indicated that proper management of ANFO over the project life could ensure compliance with ammonia standards.
Holloway Mine Matheson, Ontario, Canada	Site investigation, detailed geotechnical and hydrologic design, permitting, and construction inspection of a new sedimentation pond system for a gold mine in northern Ontario. The system includes: two new dams, two spillways, a freshwater diversion pipeline, and a wet well/CO2 injection system.
Dornod Project Mongolia	As part of a pre-feasibility study, developed a site-wide water balance for a proposed uranium mine in arid Mongolia. The plan involved using open pit inflows as the primary inflow while achieving zero discharge under most climatic conditions
NICO Project NWT, Canada	As part of a FEED study, developed site-wide water balances for several stages of operations and post-closure for a proposed mine in the Northwest Territories. Also developed a water management plan and a construction water management plan to support permitting.

Ban Houayxai Project Lao, P.D.R.	For a proposed gold project in a high relief jungle setting, developed life of mine water balances for a Tailings Management Facility with a very large upstream watershed. Also used stochastic modelling with a synthetic precipitation record to predict maximum daily spillway flows.

PROJECT EXPERIENCE – PERMITTING OF MINE WASTE FACILITIES

Victoria Creek Project Kirkland Lake, Ontario, Canada	Complete permitting services for the Victoria Creek Advanced Exploration Project near Kirkland Lake, including: closure plan, water taking permit, sedimentation pond C of A, MNR work permits, hazardous waste generator registration, septic field permit, etc. Other engineering services related to shaft location, shaft grouting, acid:base accounting of mine rock, etc.
Cigar Lake Uranium Mine Northern Saskatchewan, Canada	Preparation of a technical document supporting an EIS for each of two sites for a mine rock disposal facility for the proposed Cigar Lake Uranium Mine. The project involved siting, selection of disposal methods, detailed geochemical assessment of waste rock, conceptual design of the facility and prediction of environmental impacts.
Rabbit Lake Mill Northern Saskatchewan, Canada	Preparation of a technical document for consideration of milling Cigar Lake ore at the existing Rabbit Lake mill. Although not ultimately proceeded with, this would have involved modifications to the operations of the existing In-Pit Tailings Management Facility (a pervious surround system). Factors considered included: detailed contaminant hydrogeologic modelling, consolidation modelling, detailed planning of subaqueous tailings deposition, etc.
Shakespeare Project Agnew Lake, Ontario, Canada	Engineering, design and preparation of permit support documents for a multi stage base metal mine. Permits obtained included: Certificates of approval for a Sedimentation Pond and for a water collection and treatment system; location and structural approval of sedimentation pond dams; and two closure plans for different stages of mine development.

PROJECT EXPERIENCE – INTERNATIONAL TECHNOLOGY TRANSFER

CANMET Project Belo Horizonte, Brazil	Participated in a CANMET Project involving transfer of technology on mine closure and mine waste management to Brazil. Presented an invited lecture on planning and implementation of mine closure in Belo Horizonte, Brazil.
PerCan Project Peru	One of the lead authors of two documents prepared for the Peruvian Ministry of Energy and Mines as part of the PerCan I Project. The documents comprised a Guideline for the Evaluation of Mine Closure Plans, and a discussion paper on the technology of sub-aqueous deposition of tailings. Also presented three lectures in Lima on sub-aqueous tailings placement and mine closure planning
Asia Pacific Economic Cooperation (APEC) Asia-Pacific	One of three authors of a "Mine Closure Checklist for Governments", a guideline for the administration of mine closure planning in the Asia-Pacific region. Project was administered by Natural Resources Canada as a Canadian contribution to APEC

PROFESSIONAL AFFILIATIONS

Registered Professional Engineer, Ontario, Saskatchewan and Northwest Territories / Nunavut

Permission to Consult, Saskatchewan

PUBLICATIONS

Conference Proceedings

DeVos, Ken, Dave Ritchie and Ken Bocking. 1999. *Practical Considerations for Covering Sulphidic Tailings Deposits Situated above the Groundwater Table.* Sudbury 1999 Mining and the Environment, October. Sudbury, Canada.

Bocking, Ken, Ken DeVos, Bruce Mikkila and Glen Hall. 1999. *Closure Planning for the Falconbridge Limited Smelter Complex, Sudbury, Ontario - Issues and Experience.* Sudbury 1999 Mining and the Environment, March. Sudbury, Canada.

Martel, Ron and Ken Bocking. 2003. *Water Management and the Use of Natural Degradation in a Gold Mine Tailings Management Facility, Holt-McDermott Mine, Ontario.* Sudbury 2003 Mining and the Environment, March. Sudbury, Canada.

Bocking, Ken. 2006. *State of Practice for Disposal of Residue.* CIM Specialty Course on Iron Control in Hydrometallurgy, September. Montreal, Canada.

Bocking, K.A., K.J. DeVos and M. Butler. 2007. *Practical Considerations for Choosing Covers for Sulphidic Tailings Areas.* Mine Closure 2007, October. Santiago, Chile.

Bocking, K.A., S.N. Kam, D.E. Welch and D.A. Williams. 2009. *Management of Mine Sites After Closure.* Mine Closure 2009, September. Perth, Australia.

Bocking, K.A. and Lewis, K., 2019. *Progressive Release of Security to Incentivise and Fund Closure*, Mine Closure 2019, September. Perth, Australia.

Journal Articles

Bocking, Ken. Post-closure liabilities invited article in ACG Newsletter. *Australian Centre for Geomechanics* (December 2010, Perth Australia)