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GEOTECHNICAL news

Crews constructing the Inuvik-Tuktoyaktuk Highway

Wireless Data Collection for Geotechnical Monitoring Instrumentation

2 Wireless Data Collection Systems to quickly get you connected to your data: **RSTAR** and **DT LINK**

+ MINIMUM PER CHANNEL COST + EXTRA LONG BATTERY LIFE + LONG DISTANCE TRANSMISSION

FULLY AUTOMATED COLLECTION (REMOTELY)

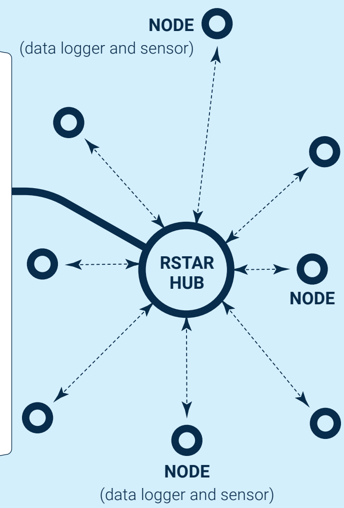
An RSTAR System uses data loggers (nodes) at the sensor level, deployed in a star topology from an active RSTAR Hub containing an RST flexDAQ Data Logger.

rstar ARRAY RADIO SERIES

FEATURES

- Up to 10 years of battery life from 1 lithium 'D' cell.
- Up to 14 km range from Hub to Node in open country. (depending on antenna type)
- Up to 255 nodes per RSTAR Hub.
- Based on 900 MHz , 868 MHz and 2.4 GHz spread spectrum band. (country dependent)

The RSTAR Hub shown left contains a flexDAQ Data Logger System with an antenna and battery. Collected data is saved to the flexDAQ memory where users can access it remotely, either on-site or off-site.



>>> Watch the video for both systems at: www.rstinstruments.com/Wireless-Data-Collection.html <<<

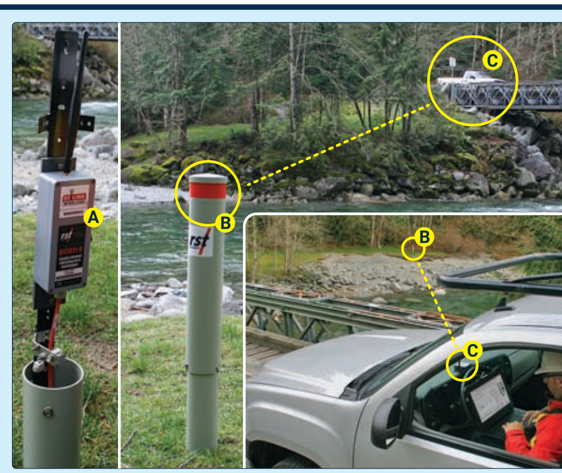
SEMI-AUTOMATED COLLECTION (ON-SITE)

DT LINK is an on-site wireless connection to RST data loggers for quick data collection. Ideal for hard to access areas where the data logger is within line of sight.

DT LINK WIRELESS

FEATURES

- Safely & easily collect data from data loggers that are in areas with poor access, trespass issues and hazardous obstacles.
- Years of battery life from 1 lithium 'D' cell.
- Range up to 800 m (900 MHz) and up to 500 m (2.4 GHz).
- Collect data in seconds with a laptop connected to DT LINK HUB.



Pictured: (A) DT LINK WIRELESS data logger, connected to a vibrating wire piezometer and housed in a (B) protective enclosure, has its data collected from a laptop connected to the (C) DT LINK HUB - all within seconds from the convenience of your vehicle.

DT SERIES DATA LOGGERS

RST's "DT Series" Data Loggers accommodate the RSTAR and DT LINK WIRELESS Systems. Compatible sensor types include: *Vibrating Wire, Potentiometers, MEMS Tilt Sensors, Strain Gauge (full bridge) Sensors, Digitally Bussed Sensors, 4-20 mA Sensors, and Thermistors.*

rst INSTRUMENTS innovation in geotechnical instrumentation

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Message from the President

Dharma Wijewickreme, President of Canadian Geotechnical Society

I hope you all enjoyed your summer and expect that you are now looking forward to new opportunities in the last quarter of 2018 and beyond.

I would like to begin by revisiting a matter that I brought up in one of my previous messages. It was a question about whether the CGS should consider connecting with and contributing to the society-at-large, complementing our traditional member-focused activities and approaches. Of course, the impetus for this suggestion is multifold. Now more so than before, there is a need to inform the public about the critical role played by the geo-professionals; this especially makes sense considering our work is mostly out of sight and not readily apparent. Moreover, it is also worth noting that considerations related to professional reliance, public confidence and transparency are getting increasing attention in the dialogues amongst the governments, industry, professional associations, and other stakeholders – again, a reminder on the connection between professionals and the Society. I believe that as the national learned society representing the geotechnical profession, we could consider outreach activities to engage and contribute beyond the membership, in turn enhancing our profession's visibility and bringing more clarity. Some of our affiliate professional organizations have already recognized the need to focus along these lines – therefore, we are not alone in this thinking.

Now, let me update with regard to the CGS accomplishments and upcoming events.

As most of you are already aware, our 71st Annual CGS Conference, GeoEdmonton 2018, will be held on September 23 - 26, 2018. The event will be held in partnership with the International Association of Hydrogeologists - Canadian National Chapter (IAH-CNC). The technical sessions will include over 250 technical papers on a range of geotechnical topics. In addition to the technical program, I invite you to attend the Legget luncheon on Monday, September 24th where our most prestigious prize will be given and the Awards Banquet on Monday evening, where CGS members will be recognized for outstanding contributions to the profession and Society. Also, make it a point to attend the annual meetings of Divisions, Committees, and the Geotechnical Research Board (GRB). The main outcomes from our annual Board meeting will be presented during the Business meeting luncheon Tuesday, September 25th. I would like to thank the **GeoEdmonton** Co-Chairs **Seán MacEoin** and **Don Lewycky** and their team for their great efforts in organizing this conference. The conference website (*http://www.geoedmonton2018.ca*) provides more details and updates.

The Geohazards 7 Conference was held in Canmore, Alberta, between June 3rd and 6th, and it was a great success with over 200 delegates in attendance. Thanks are due to the organizing committee Co-Chaired by **Michael Porter** and **Valérie Fréchette**.

Following the successful Tour of Dr O'Rourke this spring, I am pleased to let you know that **Dr. Alex Sy** (Klohn Crippen Berger) will be the 2018 Fall speaker for the 102nd Cross Canada Lecture Tour (CCLT).

The CGS Executive Committee (EC) - **Suzanne Powell** (VP Technical), **Jean Côté (V**P Communications & Member Services), **Kent Bannister** (VP Finance), **Andrea Lougheed** (Sections Representative), **Nicholas Vlachopoulos** (Divisions Representative), and **Maraika DeGroot** (Young Professionals Representative) along with volunteers from the Sections, Divisions and Committees have been working very hard on many fronts contributing to the Society activities. I would like to particularly mention the following:

a. The updated Errata for the 4th Edition of the Canadian Foundation Engineering Manual (CFEM) is now posted on the website, and we are in the process of addressing the development of online technical content of the CFEM. As indicated in my last message, the existing 4th Edition will be updated with new chapters as they become available; this will serve as the interim CFEM for the foreseeable future. The EC maintains the invitation to CGS members who would be available to help with the updates to the Manual.

b. The task force that was established to develop a Communication Strategy for the Society has made excellent progress. A report on some of the outcomes and recommendations will be issued in August 2018 for review by the EC ahead of the September Board meeting.

c. The EC has also reviewed and approved new guidelines and criteria developed for addressing requests for funding of new initiatives arising from the Sections, Divisions and Committees. The work completed by the EC and members of the Board over the last 12 months is presented in detail in the CGS Annual Report, which will be made available to the members shortly after the GeoEdmonton 2018 conference.

The CGS President-Elect **Mario Ruel** is expected to introduce the Vice Presidents of the next EC at the CGS Board of Director's meeting on September 23rd, and to the members at the Business Meeting on September 25th during the GeoEdmonton Conference.

As always, our National office has been extremely busy in the background looking after the operation of the CGS. I would like to take this moment to thank **Michel Aubertin** (Executive Director, *ExecDir@cgs.ca*), **Wayne Gibson** (Director, Administration and Finance, *cgs@cgs.ca*) and **Lisa McJunkin** (Director, Communications and Member Services, *admin@cgs.ca*) in this regard.

Thank you for reading this message, and I welcome your feedback. I look forward to meeting you in person at GeoEdmonton!

Provided by Dharma Wijewickreme
CGS President 2017 - 2018

Message du président

J'espère que vous avez tous profité de l'été et que vous anticipez de nouvelles opportunités au cours du dernier trimestre de 2018 et au-delà.

J'aimerais commencer par revenir sur une question que j'ai soulevée dans l'un de mes messages précédents. Il s'agissait d'évaluer si la SCG devait établir des liens avec le grand public et ainsi contribuer à l'ensemble de la société, en complément de nos activités et approches traditionnelles axées sur les membres. Bien entendu, le fondement de cette suggestion comporte plusieurs volets. Aujourd'hui plus qu'auparavant, il semble nécessaire d'informer le public sur le rôle fondamental joué par les géoprofessionnels, notamment parce que la majeure partie de notre travail n'est pas directement visible (ou perceptible). De plus, il convient de noter que les considérations liées à la fiabilité professionnelle, à la confiance du public et à la transparence retiennent de plus en plus l'attention dans les discussions entre les gouvernements, l'industrie, les associations professionnelles et les autres parties prenantes, ce qui constitue un autre rappel du lien entre les professionnels et la société. Je crois qu'à titre de la société savante nationale qui représente la profession géotechnique, nous pourrions envisager des activités de sensibilisation pour nous investir au-delà du cercle des membres, ce qui augmenterait la visibilité de notre profession et apporterait plus de clarté. Certaines de nos organisations professionnelles affiliées ont déjà reconnu les besoins face à ces orientations; nous ne sommes donc pas les seuls à penser de la sorte.

Maintenant, permettez-moi de faire le point sur les réalisations récentes de la SCG et les évènements à venir.

Comme la plupart d'entre vous le savent déjà, la 71e conférence annuelle de la SCG, GéoEdmonton 2018, aura lieu du 23 au 26 septembre 2018. Cet évènement sera tenu en partenariat avec la section nationale canadienne de l'Association internationale des hydrogéologues (AIH-SNC). Les sessions techniques comprendront plus de 250 présentations d'articles sur un éventail de sujets géotechniques. En plus du programme technique, je vous invite à assister au dîner Legget le lundi 24 septembre durant lequel notre prix le plus prestigieux sera remis, ainsi qu'au banquet de remise des prix en soirée, où des membres de la SCG seront reconnus pour leurs contributions exceptionnelles à la profession et à la Société. De plus, faites-vous un point d'honneur de participer aux assemblées annuelles des divisions, des comités et du Conseil de recherche en géotechnique (CRG). Les principaux résultats de l'assemblée annuelle de notre Conseil d'administration seront présentés lors du dîner du mardi 25 septembre. J'aimerais remercier les coprésidents de **GéoEdmonton 2018**, **Seán MacEoin** et **Don Lewycky**, ainsi que leur équipe pour tous les efforts déployés dans l'organisation de cette conférence. De plus amples renseignements et des nouvelles sont affichés sur le site Web de la conférence (*http://www.geoedmonton2018.ca/index.php?lang=fr*).

La conférence Géorisques 7 tenue à Canmore, en Alberta, du 3 au 6 juin, a connu un grand succès avec plus de 200 délégués. Des remerciements au comité organisateur coprésidé par **Michael Porter** et **Valérie Fréchette** sont de mise.

À la suite de la Tournée très réussie du Dr O'Rourke ce printemps, je suis heureux de vous informer que le **Dr Alex Sy** (Klohn Crippen Berger) sera le conférencier de l'automne 2018 pour la 102e Tournée de conférences transcanadienne (TCT).

Le Comité exécutif (CE) de la SCG – **Suzanne Powell** (v.-p. technique), **Jean Côté** (v.-p. aux communications et services aux membres), **Kent Bannister** (v.-p. finances), **Andrea Lougheed** (représentante des sections), **Nicholas Vlachopoulos** (représentant des divisions) et **Maraika DeGroot** (représentante des jeunes professionnels), ainsi que les bénévoles des sections, des divisions et des comités travaillent très fort sur plusieurs fronts en lien avec les activités de la Société. Je voudrais mentionner en particulier les items suivants:

a. l'erratum actualisé pour la 4e édition de la version anglaise du Manuel canadien d'ingénierie des fondations (MCIF) est maintenant affiché sur le site Web, et nous progressons sur le développement du contenu technique de la prochaine version en ligne du MCIF. Comme je l'ai indiqué dans mon dernier message, la 4e édition sera actualisée avec de nouveaux chapitres au fur et à mesure qu'ils deviendront disponibles; ceci servira de MCIF de référence pour l'avenir prévisible. Le CE maintient son invitation aux membres de la SCG qui seraient disponibles pour collaborer à la mise à jour du Manuel.

b. Le groupe de travail (GT) mis sur pied pour élaborer une stratégie de communication pour la Société a fait de grands progrès. Un rapport sur certains des résultats avec diverses recommandations sera produit pour la réunion du CE en août 2018, en prévision de l'assemblée du Conseil de direction de septembre.

c. Le CE a également élaboré et approuvé de nouvelles lignes directrices avec des critères établis pour traiter les demandes de financement de nouvelles initiatives émanant des sections, des divisions et des comités. Le travail accompli par le CE et les membres du Conseil d'administration au cours des 12 derniers mois est présenté en détail dans le Rapport annuel de la SCG, qui sera mis à la disposition des membres peu après la conférence GéoEdmonton 2018.

Le président désigné de la SCG **Mario Ruel** devrait présenter les vice-présidents du prochain CE à l'assemblée du Conseil de direction de la SCG le 23 septembre et aux membres, lors de l'assemblée du 25 septembre, durant la conférence GéoEdmonton.

Comme toujours, notre Bureau national a été extrêmement actif en arrière-plan pour assurer le bon fonctionnement de la SCG. J'aimerais profiter de cette occasion pour remercier à nouveau **Michel Aubertin** (directeur général, *ExecDir@cgs.ca*), **Wayne Gibson** (directeur, Administration et finances, *cgs@cgs.ca*) et **Lisa McJunkin** (directrice, Communications et services aux membres, *admin@cgs.ca*).

Je vous remercie d'avoir lu ce message et je vous invite à me faire part de vos commentaires. Au plaisir de vous rencontrer en personne à GéoEdmonton!

Fourni par Dharma Wijewickreme
Président de la SCG 2017-2018

From the Society

Canadian Foundation Engineering Manual Update

The Errata for the 4th Edition of the *Canadian Foundation Engineering Manual (CFEM)* has been updated and is now available on the CGS website. *CFEM* users are encouraged to visit the CGS website to download the most recent version of the Errata.

Work is continuing on developing a new online version of the *CFEM* with an estimated timeframe for completion of the entire project of approximately 2 years. In the interim, the current 4th Edition with the updated Errata is available for purchase from BiTech Publishers (*www.geotechnicalnews.com*) and continues to be the go to manual for Canadian foundation engineering design. As always, CGS members receive preferred pricing.

An update of the Limit States Design chapter (and possibly others) is underway with the intent of releasing updated chapters in digital form as an addendum to the 4th Edition while work continues on the remaining chapters. The timeframe for release of this updated chapter is early 2019.

The CGS will be issuing a formal call for a Project Manager to oversee the technical content of the *CFEM* update. This person's primary responsibility will be to oversee the completion schedule for the new manual and to liaise with chapter leads and reviewers to ensure timely content delivery.

Manuel Canadien d'ingénierie des fondations

L'erratum de la 4e édition de la version anglaise du *Manuel canadien d'ingénierie des fondations (MCIF*) a été actualisé et est maintenant disponible sur le site Web de la SCG. Nous encourageons les utilisateurs du *MCIF* à consulter le site Web de la SCG pour télécharger cette dernière version de l'erratum.

Le travail se poursuit sur l'élaboration d'une nouvelle version en ligne du *MCIF*; l'échéancier de réalisation pour l'ensemble du projet devrait s'étaler sur une période d'environ deux ans. Dans l'intervalle, l'actuelle 4e édition, avec l'erratum actualisé, peut être achetée auprès de BiTech Publishers (*http://www.geotechnicalnews.com/index.php*) ; elle continue d'être le manuel de référence pour l'analyse et la conception technique de fondations au Canada. Comme toujours, les membres de la SCG bénéficient d'un prix préférentiel.

Une mise à jour du chapitre Calcul aux états limites (et peut-être d'autres chapitres) est en cours. Nous avons l'intention de publier les chapitres actualisés en format numérique en tant qu'addenda à la 4e édition, pendant que le travail se poursuit sur les autres chapitres à venir. Ce chapitre mis à jour devrait être publié au début de 2019.

La SCG lancera officiellement un appel de candidatures pour un responsable de projet afin de superviser le contenu technique de la mise à jour du MCIF. La principale responsabilité de cette personne sera de coordonner et superviser le calendrier de réalisation du nouveau manuel et d'assurer la liaison avec les responsables et les réviseurs des chapitres pour veiller à ce que le contenu soit conforme aux attentes et prêt en temps opportun.

Canadian Foundation for Geotechnique

The 2017 Cross Canada Lectures

One of the Canadian Foundation for Geotechnique's major contributions to the CGS members is the funding of the biannual **Cross Canada Lecture Tour (CCLT)**. This funding is provided by generous corporate sponsorships from many of our member firms. We would like to acknowledge here the 2017 CCLT sponsors, without whose support our members would not benefit from having some of the best geotechnical professionals deliver excellent presentations based on their extensive knowledge and experience.

Spring 2017 CCLT sponsors

- BGC Engineering
- Klohn Crippen Berger
- Thurber Engineering

Fall 2017 CCLT sponsors

- Conetec
- Klohn Crippen Berger
- Tetra Tech Canada
- Thurber Engineering

This past year, our spring and fall lecturers were the 99th and 100th individuals to provide this most beneficial service to our members. The CCLT lecturers undertake a rather gruelling schedule to deliver these great presentations. Below are the presenters, the topics made available, and their visit schedule to each local section. I'm sure if you closely examine their schedules, you will be impressed by the stamina of our lecturers, in addition to their commitment to excellence in our profession. The Foundation is extremely grateful for their efforts and their willingness to prepare their presentations and deliver them on a whirlwind tour to our members.

Spring 2017 CCLT
Speaker Dr. Vaughn Griffiths, Colorado School of Mines

Date	Lecture Location(s)
Monday, April 10	Winnipeg
Tuesday, April 11	Regina
Wednesday, April 12	Calgary, Vancouver
Thursday, April 13	Victoria
Monday, April 17	St John's
Tuesday, April 18	Fredericton
Wednesday, April 19	Toronto
Thursday, April 20	Montreal, Quebec
Friday, April 21	Ottawa

Topics

1. Risk Assessment in Geotechnical Engineering
2. Finite Element Stability Analysis

Fall 2017 CCLT
Speaker Dr. Jean-Marie Konrad, Université Laval

Topics

1. Advances in Dam Design
2. An Engineering Framework for Thaw Consolidation
3. An Engineering Framework for Particle Breakage in Granular Soils
4. Permeability Anisotropy in Compacted Tills: Myth or Reality?

Date	Lecture Location(s)
Monday, October 16	Halifax
Tuesday, October 17	Ottawa, Kingston
Wednesday, October 18	Toronto
Friday, October 19	Montreal
Monday, October 23	Edmonton
Tuesday, October 24	Calgary
Wednesday, October 25	Vancouver
Monday, October 30	Prince George
Tuesday, October 31	Saskatoon
Wednesday, November 1	Winnipeg

A list of all the past CCLT lecturers can be found on the CGS website *http://cgs.ca/cross_canada.php*. It reads like a who's who of Canadian and international geotechnique. The CCLT has the distinction of being the longest such lecture tour anywhere in the world, and is the envy of geotechnical organizations and geotechnical professionals in many countries.

Tournées de conférences transcanadiennes de 2017

L'une des contributions les plus importantes de la Fondation canadienne de géotechnique envers les membres de la SCG est le financement de la Tournée de conférences transcanadienne (TCT). Ce financement provient de généreuses commandites offertes par de nombreuses entreprises. Nous aimerions souligner la générosité des commanditaires des TCT de 2017, sans laquelle nos membres ne pourraient accueillir ces éminents professionnels de la géotechnique et ainsi bénéficier de leurs excellentes présentations fondées sur de vastes connaissances et une expérience bien établie.

Commanditaires de la TCT du printemps 2017

- BGC Engineering
- Klohn Crippen Berger
- Thurber Engineering

Commanditaires de la TCT de l'automne 2017

- Conetec
- Klohn Crippen Berger
- Tetra Tech Canada
- Thurber Engineering

Au cours de la dernière année, les conférenciers du printemps et de l'automne étaient les 99e et 100e personnes à offrir ce service avantageux à nos membres. Les conférenciers de la TCT suivent un horaire chargé pour présenter leurs exposés. Vous trouverez ci-dessous les conférenciers, les sujets abordés, ainsi que l' horaire des présentations aux diverses sections locales. J'ai la certitude que si vous analysez leur horaire, vous serez impressionnés par l'énergie déployée par nos conférenciers et par leur engagement en matière d'excellence au sein de notre profession. La Fondation les remercie chaleureusement de leurs efforts et de leur volonté de préparer et de présenter des exposés de très grande qualité à nos membres dans le cadre de cette tournée très exigeante .

TCT du printemps 2017 Notre conférencier était le Dr Vaughan Griffiths, de la Colorado School of Mines

Date	Ville(s)
Lundi 10 avril	Winnipeg
Mardi 11 avril	Regina
Mercredi 12 avril	Calgary et Vancouver
Jeudi 13 avril	Victoria
Lundi 17 avril	St. John's
Mardi 18 avril	Fredericton
Mercredi 19 avril	Toronto
Jeudi 20 avril	Montréal et Québec
Vendredi 21 avril	Ottawa

Sujets

1. Risk Assessment in Geotechnical Engineering (Évaluation des risques en géotechnique)
2. Finite Element Stability Analysis (Analyse de la stabilité par la méthode des éléments finis)

TCT de l'automne 2017 Notre conférencier était le Dr Jean-Marie Konrad, de l'Université Laval

Sujets

3. Advances in Dam Design (Progrès pour la conception des barrages)
4. An Engineering Framework for Thaw Consolidation (Un cadre d'ingénierie pour la consolidation due au dégel)

Date	Ville(s)
Lundi 16 octobre	Halifax
Mardi 17 octobre	Ottawa et Kingston
Mercredi 18 octobre	Toronto
Jeudi 19 octobre	Montréal
Lundi 23 octobre	Edmonton
Mardi 24 octobre	Calgary
Mercredi 25 octobre	Vancouver
Lundi 30 octobre	Prince George
Mardi 31 octobre	Saskatoon
Mercredi 1er novembre	Winnipeg

5. An Engineering Framework for Particle Breakage in Granular Soils (Un cadre d'ingénierie pour la fragmentation de particules dans des sols granulaires)
6. Permeability Anisotropy in Compacted Tills: Myth or Reality? (L'anisotropie de la perméabilité dans des tills glaciaires compactés : Mythe ou réalité?)

La liste des précédents conférenciers de la TCT se trouve sur le site Web de la SCG, à *http://www.cgs.ca/cross_canada.php?lang=fr.* Elle se lit comme un répertoire du gratin de la communauté géotechnique canadienne et internationale. La TCT se distingue en étant la plus longue tournée de conférences du genre dans le monde et elle fait l'envie d'organisations géotechniques et de professionnels en géotechnique de plusieurs pays.

Conferences and Seminars

71st Canadian Geotechnical Conference and the 13th Joint CGS/IAH-CNC Groundwater Conference September 23 to 26, 2018, Edmonton, Alberta, Canada

The **Geotechnical Society of Edmonton (GSE)** and the **Canadian Geotechnical Society (CGS)** in collaboration with the **Canadian National Chapter of the International Association of Hydrogeologists (IAH-CNC),** invite you to **GeoEdmonton 2018**, the 71st Canadian Geotechnical Conference and the 13th Joint CGS/IAH-CNC Groundwater Conference. The conference will be held at the Shaw Conference Centre in Edmonton, Alberta, Canada from **Sunday, September 23 to Wednesday, September 26, 2018.** This spectacular facility is one of Canada's premier conference venues and is itself a geotechnical achievement, being constructed on the flank of an active landslide overlooking Edmonton's beautiful river valley in the heart of downtown.

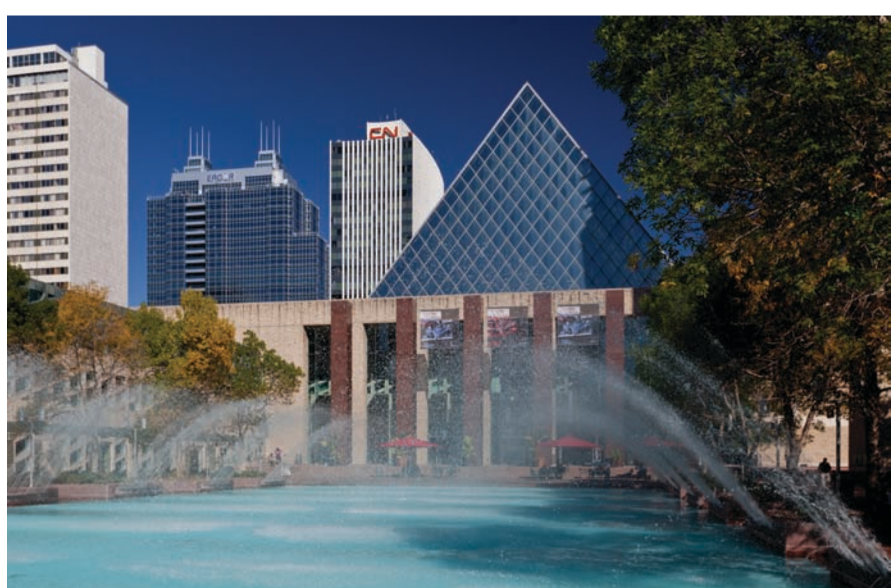
Edmonton was founded on the banks of the North Saskatchewan River and served as a Hudson's Bay Company trading outpost that grew to become Canada's Gateway to the North and is Alberta's Capital City. With a metro population of over 1.3 million people, Edmonton has an open and welcoming atmosphere. Also known as the Festival City, Edmonton showcases its local and international talent and diversity through various festivals like its annual Heritage Festival and the second largest Fringe Theatre Festival in the world. Boasting the longest stretch of connected urban parkland in North America and just steps from the conference venue, Edmonton is also a wonderful place to enjoy nature without leaving the city's limits.

The theme for GeoEdmonton 2018 is **Transportation Géotechnique - Moving Forward.** Much of Canada's prosperity is founded on its vast network of railways, pipelines, highways, and waterways. This conference intends to highlight recent achievements in transportation development and their associated geohazards. The technical program will cover a wide range of geotechnical and hydrogeological topics, including specialty sessions that are of local and national relevance. The official languages for the conference will be English and French.

With over 260 papers submitted to date, the annual CGS Conference will once again be offering a comprehensive technical program in 2018. In addition to the conference, five short courses are also being offered on Sunday, September 23. **GeoEdmonton 2018** is also pleased to have been asked to launch CGS's *History of Women in Canadian Geotechnique* and will feature 12 profiles of prominent individuals, past and present, at Wednesday's conference closing lunch. In addition to the technical program and plenary sessions, the conference will include a complement of distinguished keynote speakers and technical tours. The conference will also be supported by over 70 exhibitors.

Along with the traditional Ice Breaker Reception, GeoEdmonton is also pleased to host a special Student/ Young Professional mixer, giving our newest members an opportunity to meet and talk with some of the senior Board members and prominent practitioners in an informal social setting prior to the Ice Breaker. Also returning will be the popular GEOpardy competition.

In addition to honouring our award winners at the Awards Gala on Monday, September 24, the Gala will be featuring the world acclaimed Shumka Dance Company. More than 50 years of performance history is reflected in the Shumka's signature music and dance style. While maintaining deep respect for their heritage, Shumka continually challenges conventional boundaries in order to define the



Edmonton City Hall

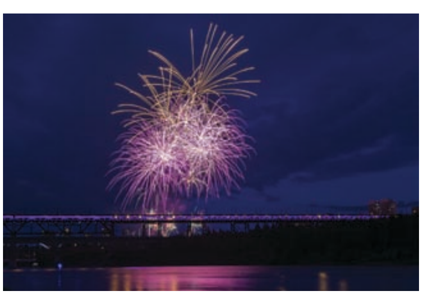
experience of Ukrainian dance in the context of today's society.

Local Colour Night will be held at the Shaw Conference Centre on the upper level of Hall D, which provides sweeping views of the river and the city lights. The theme for the evening will be a Taste of Edmonton which will present several local entertainment acts throughout the evening on a main stage, reflecting the city's ethnic and cultural diversity. It will also feature an Alberta-themed menu with local craft beers and drinks.

Not to be forgotten, a varied menu of activities to select has also been prepared for any accompanying persons wishing to tour various city attractions during the day.

Be sure to join us September 23-26, 2018 for some Alberta geotechnical hospitality at Edmonton's Shaw Conference Centre. See you in Edmonton!

For the latest information about the conference, please visit the conference website at *http://www.geoedmonton2018.ca.*



Canada Day Fireworks over the High Level Bridge.

La 71e conférence canadienne de géotechnique et la 13e conférence conjointe SCG/AIH-SNC sur les eaux souterraines Du 23 au 26 septembre 2018, à Edmonton, en Alberta, au Canada

La Société géotechnique d'Edmonton (GSE) et la Société canadienne de géotechnique (SCG), en collaboration avec la section nationale canadienne de l'Association internationale des hydrogéologues (AIH-SNC), vous invite à GéoEdmonton 2018, la 71e conférence canadienne de géotechnique et la 13e conférence conjointe SCG/AIH-SNC sur les eaux souterraines. La conférence aura lieu au Centre des congrès Shaw à Edmonton, en Alberta, au Canada, du dimanche 23 septembre au mercredi 26 septembre 2018. Cet établissement spectaculaire est l'un des principaux lieux de congrès du Canada et est aussi une réalisation géotechnique, puisqu'il est construit sur le flanc d'une zone de glissement de terrain active qui surplombe la magnifique vallée fluviale d'Edmonton, au cœur du centre-ville.

Edmonton a été fondée sur les rives de la rivière Saskatchewan Nord et a servi d'avant-poste commercial de la Compagnie de la Baie d'Hudson. Elle est devenue la porte d'entrée du Canada vers le Nord et la capitale de l'Alberta. Avec une population métropolitaine de plus de 1,3 million d'habitants, Edmonton a une atmosphère chaleureuse et accueillante. Également connue sous le nom de la ville des festivals, Edmonton met en valeur son talent local et international et sa diversité par l'entremise de divers festivals, comme son Festival du patrimoine annuel et le deuxième plus important festival de théâtre expérimental (Fringe Theatre Festival) au monde. Dotée de la plus longue étendue de forêt-parc urbaine en Amérique du Nord à seulement quelques pas du lieu de la conférence, Edmonton est aussi un endroit merveilleux pour profiter de la nature sans quitter les limites de la ville.

Le thème de GéoEdmonton 2018 est La géotechnique des transports – Ouvrir la voie. La prospérité du Canada repose en grande partie sur son vaste réseau de chemins de fer, de pipelines, de routes et de voies navigables. Cette conférence vise à mettre en lumière les récentes réalisations en matière de développement des transports et les géorisques qui y sont associés. Le programme technique couvrira un large éventail de sujets géotechniques et hydrogéologiques, y compris des séances spécialisées d'intérêt local et national. En plus du programme technique et des séances plénières, la conférence comprendra un éventail d'éminents conférenciers d'honneur et d'activités sociales, ainsi que cinq cours intensifs de haut calibre et une visite technique. Les langues officielles de la conférence seront le français et l'anglais.

Avec plus de 260 articles soumis à ce jour, la conférence annuelle 2018 de la SCG offrira à nouveau un programme technique complet. En plus de la conférence, cinq cours intensifs sont également proposés le dimanche 23 septembre. L'équipe de GéoEdmonton 2018 est également heureuse d'avoir été invitée à donner le coup d'envoi du projet de la SCG Histoire des femmes dans le domaine de la géotechnique au Canada et présentera 12 profils de personnalités éminentes, d'hier et d'aujourd'hui, lors du dîner de clôture de la conférence le mercredi midi. En plus du programme technique et des séances plénières, la conférence comprendra un éventail d'éminents conférenciers invités et de visites techniques. La conférence rassemblera également plus de 70 exposants.

Tout juste avant la réception d'accueil traditionnelle, l'équipe de GéoEdmonton 2018 tiendra une séance de réseautage pour les étudiants et les jeunes professionnels, afin de donner à ces nouveaux membres l'occasion de rencontrer des dirigeants du Conseil de direction et des géopraticiens renommés dans une ambiance décontractée. Le concours GEOpardy que vous aimez tant est aussi de retour.

En plus de rendre hommage à nos lauréats, le Gala de remise des prix du lundi 24 septembre mettra en vedette la troupe de danse Shumka acclamée dans le monde entier. Les styles de musique et de danse de la troupe Shumka témoignent d'une expérience de plus de 50 ans. Tout en rendant un hommage respectueux à leur patrimoine, les danseurs de la troupe repoussent constamment les frontières traditionnelles afin de définir la danse ukrainienne dans un contexte moderne.

La soirée à saveur locale aura lieu au Centre des congrès Shaw au deuxième étage du Hall D, où vous aurez une vue majestueuse sur la rivière et les lumières de la ville. La soirée se déroulera sous le thème « Pleins feux sur Edmonton » et mettra à l'honneur sur la scène principale des interprètes locaux, reflétant la diversité ethnique et culturelle de la ville. Le menu sera sous le thème de l'Alberta et vous proposera des bières artisanales et des boissons locales.

Il ne faut pas oublier que diverses activités seront offertes aux accompagnateurs qui désirent visiter la ville durant la journée.

Soyez des nôtres du 23 au 26 septembre 2018 pour bénéficier de l'hospitalité géotechnique albertaine au Centre des congrès Shaw d'Edmonton. Au plaisir de se voir à Edmonton!

Pour obtenir les derniers renseignements sur la conférence, veuillez consulter son site Web, à *http://www.geoedmonton2018.ca/index.php?lang=fr.*

Division and Committee News

If you have thought about getting involved with the CGS as a volunteer at your local Section or at the national Division or Committee level, contact us for more information about some upcoming opportunities to participate. You will find it a rewarding and beneficial experience.

We will be looking for feedback on some important topics over the next few months. Please check out our website *www.cgs.ca*; email Lisa at *admin@cgs.ca* or check out the comment cards at the GeoEdmonton conference. We are looking forward to hearing from you all!

Have an interesting Geotechnical related story or project that you would like to see profiled in an upcoming issue? Send your ideas to Lisa at *admin@cgs.ca*. We are looking for interesting material.

Nouvelles des divisions et des comités

Si vous avez envisagé de contribuer à la SCG en tant que bénévole de votre section locale ou au niveau d'une division ou d'un comité national, communiquez avec nous pour obtenir de plus amples renseignements sur les occasions de participation. Vous trouverez qu'il s'agit d'une expérience enrichissante et positive.

Nous voudrons obtenir des avis sur d'importants sujets au cours des prochains mois. Veuillez consulter notre site Web, *www.cgs.ca*, écrire à M^{me} McJunkin, à *admin@cgs.ca* ou utiliser les cartes de commentaires disponibles à la conférence GéoEdmonton. Nous sommes impatients de connaître votre opinion!

Vous avez une histoire ou un projet intéressant lié à la géotechnique que vous aimeriez *voir paraître dans un prochain numéro? Envoyez vos idées à M^{me} McJunkin*, à *admin@cgs.ca*. Nous sommes à la recherche d'éléments intéressants.

Rock Mechanics and Engineering Geology

Short Course on Practical Aspects of Core Logging for Engineering Purposes

Instructors: **Dr. Adam Coulson** (Lead Instructor - Wood), **Ms. Éliane Cabot** (Wood), **Dr. Mohsen Nicksiar** (Chair RMD – SNC Lavalin Inc.), **Dr. Samuel Proskin** (Past-Chair RMD – Thurber Engineering), and **Dr. Nicholas Vlachopoulos** (Chair EGD – Royal Military College of Canada).

Following up from a suggestion made by the past Chair of the CGS Rock Mechanics Division, **Dr. Samuel Proskin**, the Rock Mechanics Division (RMD) and Engineering Geology Division (EGD) have collaborated in order to plan and prepare a short course at GeoEdmonton based on the practical and hands-on aspects for Core Logging for engineering purposes. We are grateful to Wood that have taken a lead role in the preparation and conduct of this short course. We also appreciate the fiscal support provided by CARMA, to the Mineral Core Research Facility (Alberta Geological Survey) and University

Cores.

of Alberta for the provision of core samples.

It has been seen in industry that there are not many opportunities afforded to young and mid-career Geoprofessionals to obtain hands-on experience with regards to the planning, data collection, processing, handling and analysis of core samples. As such, the objective of this short course is to familiarize its participants with a comprehensive core logging methodology, developed on hard rock core, in order to provide reliable input parameters for the development of rock mass ratings. In addition, challenges for logging soft rock core will be addressed with consideration to hydrothermal alteration and rock degradation. Recommendations for core sampling for further laboratory strength testing will be provided along with tips on additional field measurements.

The short course will be conducted in Edmonton, Alberta as part of the GeoEdmonton conference on Sunday, September 23rd 2018. More details are provided at *http://www.geoedmonton2018.ca/workshops.php#sc4*

The workshop will include ISRM standards along with industry best practices for core logging procedure including, the review of:

- planning of a coring program from a Site Investigation point of view;
- general requirements for borehole logging;
- collection of specific geomechanical information to be recorded on logs, on a run basis (such as core recovery and RQD, rock weathering, rock strength, descriptive geology) and on a discontinuity basis (such as orientation, shape, roughness, alteration, infill type and thickness);
- common challenges, issues encountered during logging which impact on data processing;
- relevance and use of core logging for rock mass classification
- borehole log records, formats and software;
- specifics for core photo library;
- other field measurements on core;
- handling, labelling and preservation of rock cores;
- core storage.

We look forward to seeing everyone at GeoEdmonton and hope you consider signing up for this course!

Submitted by Dr. Nicholas Vlachopoulos
Chair of the Engineering Geology Division

Committee News

Heritage Committee

Make sure to check out the CGS Heritage Virtual Archives on the website. You will be surprised by how much information is there! *http://www.cgs.ca/history_overview.php*

Canadian Geotechnical Society Virtual Archives

There are rich but rarely used resources in Canada that consist of files containing historical information on geotechnical laboratory and field research, geotechnical investigations, work of committees and geotechnical expertise. Ways to identify and use these resources have been developed by the Heritage Committee of the Canadian Geotechnical Society in the form of virtual archives on the CGS web site, where the location and content of accessible historical geotechnical material are given.

CGS members and others are invited to submit candidate material for consideration. The submission should give the location of the material, a description of its nature and content, its historical significance and the conditions under which it can be accessed. Do not submit physical archival material as the Society has no space to store it, however electronic copies of photographs or materials are welcome.

History of Local Sections of the Canadian Geotechnical Society

The Heritage Committee believes that the history of the local sections of the Canadian Geotechnical Society are a valuable part of the Society and its members. The CGS Heritage Committee would like to assemble if at all possible, a collection of historical summaries of all the sections. Hopefully every local chapter of the CGS will take the time to gather their archives and write their own history.

Your contribution to the CGS Virtual Archives web page should be sent to the Chair of the Heritage Committee, Heinrich Heinz, P.Eng. at *hheinz@thurber.ca.*

Editor

Don Lewycky, P.Eng.
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Email: don.lewycky@gmail.com

It is with great sadness that the Canadian Geotechnical Society announces the passing of two its long-serving members: Gordon C. McRostie died on June 9 at age 96 and Owen L. White died on June 23, 2018 at age 92. Their technical obituaries, written by colleagues Michel St-Louis, and John Gartner and Doug VanDine, respectively, are on the CGS website at 'Lives Lived' *http://www.cgs.ca/virtual_archives_lives_lived.php*. The following is a summary of their professional contributions. Both these gentlemen will be missed.

Gordon C. McRostie (1922 - 2018)

Gordon McRostie.

Gordon McRostie was born in Sainte-Anne-de-Bellevue, Québec, graduated from the University of Toronto with a BSc in Civil Engineering in 1944 and moved to Ottawa in 1945. After gaining a few years of practical experience, he opened his own geotechnical engineering practice in Ottawa in 1950, one of the first geotechnical consulting firms in Canada. In April 2006, Gordon merged his company, McRostie, Genest, St-Louis & Associates, with Golder Associates' Ottawa office, where he continued to contribute to the profession until very recently.

In 1961, Gordon helped form the Geotechnical Engineering Division of the Engineering Institute of Canada, which became the Canadian Geotechnical Society (CGS) in 1972. In 1963, Gordon was one of 10 geotechnical professionals who financially backed the first year of the *Canadian Geotechnical Journal*. He helped organize the 1st Civilian Soil Mechanics Conference (the forerunner of the CGS Annual Conference) in Ottawa in 1947, and was one of forty delegates to attend that event. Gordon attended 68 of the 70 CGS annual conferences in his lifetime, being on the organizing committees of a number of those conferences, including the 70th CGS Annual Conference held in Ottawa in 2017.

Gordon's exceptional work has been honored with a number of awards over the years. In 1997, Gordon received the R.F. Legget Award, the most senior and prestigious award presented by the Canadian Geotechnical Society. He received the Canadian Pacific Railway Award in 1995 from the Engineering Institute of Canada in recognition of his many years of service and leadership. In 1996, Gordon, L. Morissette and M.W. St-Louis were awarded the Gzowski Medal by the Canadian Society for Civil Engineering for best paper on a civil engineering subject in the area of surveying, structural engineering and heavy construction. The same three co-authors received the CGS's RM Quigley Award in 2002 for their outstanding contribution to the *Canadian Geotechnical Journal.* In 2015, Gordon received the first Honorary Life Membership from the CGS for his life-long contribution and dedication to the Society and to the geotechnical profession in Canada.

Gordon had a long-standing career in geotechnical engineering and will be remembered fondly for his willingness to share his knowledge. His professional life was amplified by a personal life filled with adventure - from skydiving for his 90th birthday, climbing to the base camp of Mount Everest and to Machu Picchu, and being shipwrecked in Antarctica. He traveled the world and made sure to live his life to the fullest.

Gordon was a pioneer in geotechnical engineering and above all a wonderful human being. His insurmountable generosity and lively spirit was infectious, and he was a great mentor to so many of his colleagues.

Owen L. White (1926 - 2018)

Owen White.

Owen White was born in Melbourne, Australia, and graduated with an Associate Diploma of Secondary Metallurgy from the Royal Melbourne Institute of Technology in 1950. While working in Melbourne, he studied part time towards a BSc in geology, mining and metallurgy at the University of Melbourne, graduating in 1958. That year, he moved to Canada to pursue a Master's degree in geology and civil engineering at the University of Toronto.

Upon graduation in 1960, Owen briefly worked as a soils engineer for Racey, McCallum & Associates, a geotechnical consulting engineering firm in Toronto, before being offered the position of Lecturer in the Department of Civil Engineering at the, then, new University of Waterloo. He became an Assistant Professor, then Associate Professor, and then was cross appointed with the Department of Earth Sciences. While at Waterloo, Owen also attended the University of Illinois where he completed a Ph.D. in engineering geology under Prof. Don Deere, graduating in 1970. Owen left Waterloo in 1977 and joined the Ontario Geological Survey as Chief, Engineering and Terrain Geology Section and worked in that capacity until he retired in 1991.

In 1973, he founded the Engineering Geology Division of the Canadian Geotechnical Society (the CGS's first division), and served as its chair until 1979. In 1982 he was elected Vice President North America of the International Association of Engineering Geology and Environment, and served as the IAEG President from 1986-1990. Owen was awarded the IAEG's most senior award, the Hans Cloos Medal, in 1998.

Besides the Hans Cloos Medal, Owen's awards and honours were many: Fellow of the Geological Society of London (1975); Fellow of the Engineering Institute of Canada (1980); the Thomas Roy Award from the CGS's Engineering Geology Division (1996); the EB Burwell Jr. Award from the Geological Society of America's Engineering Geology Division (1998); a Special Achievement Award from the Prospectors and Developers Association of Canada (2003); and the RF Legget Medal, the CGS's highest award, for his contributions to the geotechnical community, in particular, engineering geology (2006).

In retirement, Owen continued doing some lecturing, in Canada and abroad, some consulting and some research and writing. In 1998, he co-edited along with Dr. P.F. Karrow, a 500-page Geological Association of Canada special paper on "Urban Geology of Canadian Cities".

Owen's other interests included stamp and postmark collecting, and the military. He was a *Fellow of the Royal Philatelic Society of Canada*, was attached to the Royal Australian Engineers in Melbourne and the 2 Field Engineer Regiment in Toronto, and was a member of the Military Engineers Association of Canada until his death.

Owen was a taciturn man with bushy eyebrows and a quiet Australian voice. During his career and in retirement he accomplished a great deal, and had a profound effect on engineering geology in Canada and abroad.

History of the Development of the Canadian Foundation Engineering Manual/ Manuel Canadien d'Ingénierie des Fondations Part 3 of 4

Doug VanDine

Introduction to Part 3 of the Series

Parts 1 and 2 of this series, published in the March and June 2018 issues, covered the beginnings of the manual and brought the history up to the '*1985 Second Edition*'. This part covers the '*1989 French Edition*', the '*1992 Third Edition*' (in English) and the '*1994 French Edition*'. If you can't wait to read Part 4, the entire article is on the CGS website (see *http://www.cgs.ca/engineering_manual_overview.php?lang=en*)

1989 French Edition of the CFEM (MCIF)

In the late 1980s, Robert Chapuis (École Polytechnique), assisted primarily by Pierre Morin (Memorial University of Newfoundland), translated the *1985 Second Edition*, and in so doing corrected a number of errors they found in the English version–errors mainly associated with unit conversions from Imperial to metric.

The resulting 378-page French version, known as the Manuel Canadien d'Ingénierie des Fondations (*MCIF*) was published by the CGS (in French, La Société canadienne de geotechnique, or SCG) in 1989 and distributed by BiTech Publishers (SCG, 1989, Figure 1). Although based on the *1985 Second Edition* of the *CFEM*, the *MCIF* was not identified as either the first or second edition.

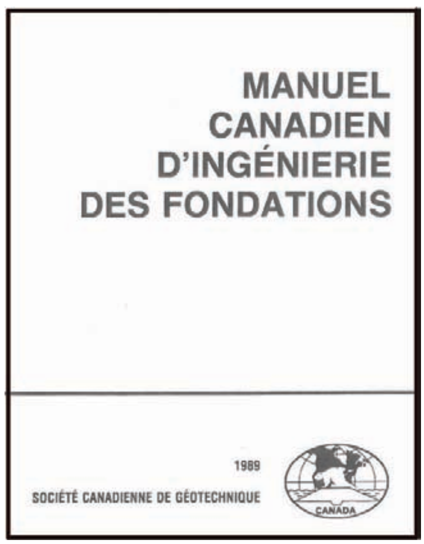

Figure 1: Cover of the 1989 French Edition.

Translated from the preface of the *1989 French Edition*:

"The contribution [to Canadian geotechnique] of Francophone members, very active in the profession and within the [Canadian Geotechnical] Society, has necessitated the translation of this Manual, which is essential to learning the important principles and geotechnical methods at the university level".

It is not known how many copies of the *1989 French Edition* were printed, but likely less than 1,000. They sold for $132 for CGS members, $147 for non-members and $84 for students.

Late 1980s

By the late-1980s, the *CFEM* and the *MCIF* were gaining acceptance and copies were being sold quite widely across Canada and internationally. Besides geotechnical engineering consultants, the manual was being adopted by many Canadian universities as a text book for geotechnical engineering courses. The revenue generated from the sales of the *CFEM* and the *MCIF* was starting to make a positive effect on the revenue of the Society and, at least partially because of this revenue, the Society was able to maintain its relatively low membership fees.

As an aside, when the author taught at the Institute of Engineering in Kathmandu, Nepal, in 1993-1994, the *1985 Second Edition of the CFEM* was being used there as a textbook. The document was an unauthorized Asian reproduction of the *1985 Second Edition*, printed on light-weight paper, and sold at a fraction of the Canadian price. Others have reported a widespread use of various editions of the Manual in countries such as Hong Kong and Australia.

1992 Third Edition of the CFEM

The preface of the *1992 Third Edition* (CGS, 1992, Figure 2) identified the main contributors of that edition as follows (their organizations at that time were not identified, but have been added).

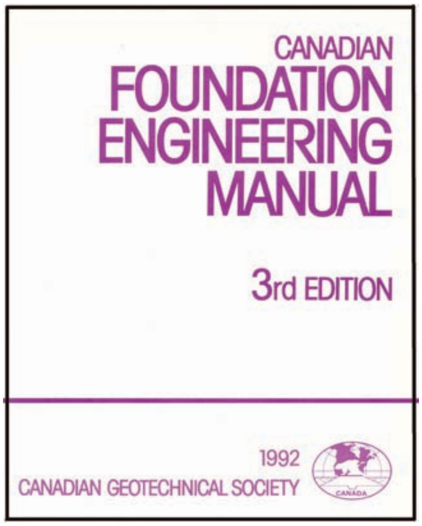

Figure 2: Cover of the 1992 Third Edition.

Z. (Dan) Eisenstein (Editor), University of Alberta; P.C. (Peter) Lighthall (co-Editor), Klohn Crippen;and CGS VP Technical, R.J. (Richard) Bathurst, Royal Military College; J.R. (John) Busbridge, Golder Associates; B.H. (Bengt) Fellenius, University of Ottawa; D.G. (Del) Fredlund, University of Saskatchewan; D.W. (Don) Hayley, EBA Consultants; E.C. (Ed) McRoberts, Hardy BBT; R.L. (Robert) Martin, Hardy BBT; I.D. (Ian) Moore, Queen's University; K.R. (Ken) Peaker, Shaheen and Peaker (formerly of the Trow Group); G.P. (Gerry) Raymond, Queen's University; R.K. (Kerry) Rowe, University of Western Ontario; V.A. (Victor) Sowa, Klohn Crippen; and, F. (François) Tavenas, Université Laval and CGS President (1991-1992) (and a member of the early 1970s NRC Subcommittee on Foundations).

Bengt Fellenius was the only member directly associated with the *1985 Second Edition*, however, he admits he had little to do with the *1992 Third Edition.* For some reason, Alex Sy of Klohn Crippen was inadvertently omitted from the above list.

The preface also credited the four geotechnical engineers who guided the *1985 Second Edition*. In addition, the preface of the *1992 Third Edition* credited two additional individuals, Trish Pharey and Bonnie Banks (both of Klohn Crippen), "who were responsible for compiling the [*1992 Third Edition* of the] Manual on a word processor [MSWord], and who patiently undertook the numerous edits".

The *1992 Third Edition* revised and enlarged the *1985 Second Edition*, this time to a 512-page document with a wider column width on the page. The 'four parts' of previous editions were eliminated; the topics were simply organized by chapters, but for the most part in the same order as in the *1978 First Edition* and the *1985 Second Edition.*

Among other changes, the brief mention of "geotextiles" in the *1985 Second Edition*, was expanded to an entire 39-page chapter on various uses of "geosynthetics" in the *1992 Third Edition*. In addition, the chapter on Deep Foundations was extensively updated.

The errors in the conversions from Imperial units to metric units, which appeared in the *1985 Second Edition* and were corrected in the *1989 French Edition*, were also corrected in the *1992 Third Edition*.

It is interesting to note that a subsequent page of errata in the *1992 Third Edition* had the following "Notice to Users".

> "The use of partial factors of safety in Limit State [sic] Design of Foundations, while advocated in some foreign countries, is currently under review in Canada and the United States. Users of the Canadian Foundation Engineering Manual are advised to exercise caution in applying those sections of the Manual referring to partial factors of safety."

The *1992 Third Edition* was distributed by Bitech Publishers. Approximately 1,800 copies were printed and they sold for $112 for CGS-members, $127 for non-members and $64 for students.

1994 Second French Edition of the CFEM (MCIF)

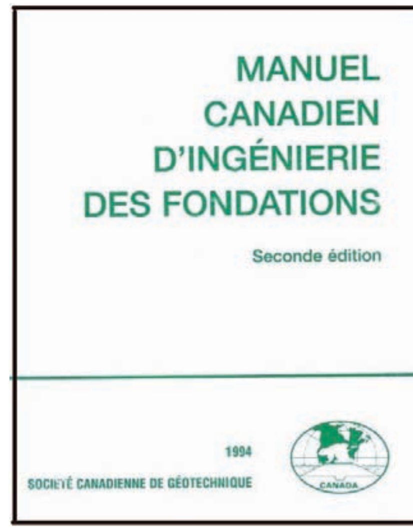

Figure 3: Cover of the 1994 Second French Edition.

The *1992 Third Edition* of the *CFEM* was translated primarily by, and under the leadership of, Pierre Morin (Memorial University of Newfoundland). Published by the CGS (SCG) in 1994 and distributed by BiTech Publishers, this 558-page document (SCG, 1994, Figure 3) was titled the *MCIF Second Edition*, even though it was a translation of the *1992 Third Edition* of the *CFEM*. This has caused some confusion, because no 'Third Edition' of the *MCIF* was ever produced.

Approximately 1,100 copies of the *1994 Second French Edition* were printed. The selling price is not known.

To be continued....

Part 4, the last of this series, will cover the *'2006 Fourth Edition'* (in English) and the *'2013 Fourth French Edition'*, and will look forward towards the future edition of the CFEM/MCIF.

Acknowledgements

Many individuals assisted the author in locating the older editions of the manual, providing valuable additional information, and providing excellent review comments on numerous drafts. They will be appropriately acknowl-

edged in Part 4. The author, however, accepts responsibility for any errors or misinterpretations of facts. If readers have additional information, or comments, on the history of the development of the *CFEM* and the *MCIF*, please send them to *vandine@islandnet.com.*

References for Part 3

Canadian Geotechnical Society (CGS), 1992, Canadian Foundation Engineering Manual, 3rd Edition, published by the CGS c/o BiTech Publishers Ltd., Vancouver, BC, 512 p.

Société Canadienne de Géotechnique (SCG), 1989, Manuel Canadien d'Ingénierie des Fondations, published by the CGS c/o BiTech Publishers Ltd., Vancouver, BC, 378 p.

Société Canadienne de Géotechnique (SCG), 1994, Manuel Canadien d'Ingénierie des Fondations, 2ème Édition, published by the CGS c/o BiTech Publishers Ltd., Vancouver, BC, 558 p.

Inuvik to Tuktoyaktuk Highway

This is the CGS Cold Regions Geotechnology Division's first contribution to the "From the CGS Board" portion of Geotechnical News*. In it, Ed Grozic, of Tetra Tech Canada Inc., describes the challenges, design and construction of Canada's first highway entirely constructed on continuous permafrost terrain. Jack Seto, Chair CGS Cold Region Division.*

Introduction

The Inuvik to Tuktoyaktuk Highway (ITH) is the first Canadian highway constructed entirely on sensitive, ice-rich, continuous permafrost terrain, and is the only Canadian highway to the Arctic Ocean. The 137-km two-lane, gravel surface road connects the communities of Inuvik and Tuktoyaktuk, Northwest Territories (Figure 1), and was opened on November 15, 2017.

The owner, the Government of the Northwest Territories, required the highway to be resilient, cost-effective and constructible, with foreseeable maintenance costs for a 75-year design life. The project involved placing approximately 4.8 M m^3 of embankment fill, constructing 8 bridges and installing over 300 culverts.

Figure 1. Inuvik to Tuktoyaktuk Highway location.

Maintaining the existing permafrost condition was a key element in the design and construction of the highway. If the underlying, ice-rich soils were to thaw, the road embankment and subgrade could become unstable through loss of soil strength and thaw-settlement. The design approach was to construct a 'fill-only' embankment to insulate and maintain the underlying permafrost condition, thus creating a stable, permanently frozen foundation.

Detailed planning commenced in 2008; an environmental impact statement was issued in 2011; environmental reviews extended through 2012 and formal approval was given in early 2013. Geotechnical investigations were undertaken during winters of 2012 and 2013. Construction commenced in early 2014 and was completed in late 2017, with the work primarily undertaken in the winter months. The prime contractor, was EGTNW Ltd., a joint venture between Tuktoyaktuk-based E. Grubens Transport Ltd. and Inuvik-based Northwind Industries Ltd. Construction advanced from both communities.

Environment

Permafrost. The ITH is located within a zone of continuous permafrost. Permafrost is defined as a ground condition that remains at or below 0˚C for at least two consecutive years. Along the alignment, ground temperatures at depth range from -2˚C to -5˚C. Where there is organic cover, the thickness of the active layer (the surface layer that freezes every winter and thaws every summer) varies between 0.6 m and 1.5 m. On elevated, exposed and south facing slopes, the active layer can be >2.0 m.

The mineral soils in the region are characteristically ice-rich, with ground ice content typically >20% by volume. Ice-rich soils limit the infiltration of water and promote the accumulation of thick organic material on surface.

Surficial Geology. The southern third of the alignment crosses the eastern extension of the Caribou Hills on the edge of the Anderson Plain, and consists of mainly ground moraines and unconsolidated sediments comprising glaciofluvial, lacustrine, and organics, with varying quantities of ground ice. Topographic relief along this section reflects the bedrock surface, but bedrock is rarely exposed. Overburden is <50 m thick. The northern two-thirds of the alignment crosses the Coastal Plain and is littered with lakes. Unconsolidated sediments include ground moraines, ice-contact tills, and glaciofluvial and glaciolacustrine deposits—all containing ground ice and massive ice lenses. For design purposes, the diverse surficial geology along the alignment was generalized into morainal, glaciofluvial, lacustrine, alluvial/colluvial, and organic deposits.

Geotechnical permafrost considerations

The two, more significant, geotechnical design considerations that needed to be considered were related to permafrost: the sensitive ice-rich soils and the management of surface water. When the amount of water contained in the frozen soil is greater than in the soil after thaw, the soil is considered to be ice-rich. Ice-rich soils are highly sensitive to thermal disturbances, which results in thaw settlement (Figure 2), and can exhibit significant loss of soil strength and instability when thawed. Both flowing and ponded surface water transfer heat from the water to the ground ice resulting in thaw conditions.

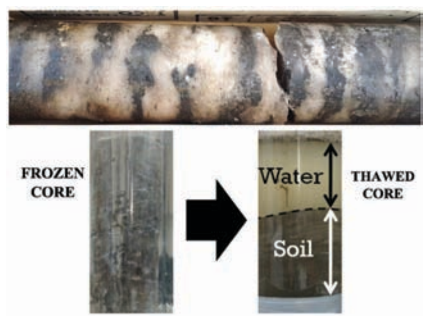

Figure 2. Ice-rich soil; frozen and thawed.

The primary alignment consideration was to avoid, where possible, unfavourable permafrost terrain distinctive in the region, including polygonal ground, thick organics, thermokarst lakes, retrogressive thaw flow slides and pingos, while minimizing overall length.

Polygonal ground is found primarily in low-lying, poorly drained areas, and is indicative of ice-rich soils with vertical ice wedges forming around the polygon perimeter and extending several metres below ground. The ITH routed around or alongside polygonal terrain where possible, Figure 3.

Thick organics deposits, up to several metres thick, occur as peat, fen or peat-fen complexes that overlie mineral soil, typically on flat terrain.

Thermokarst lakes develop due to surface subsidence resulting from the melting of ice-rich soils where the surface water cannot drain. The formation of small lakes leads to further degradation of the permafrost condition and lake expansion (Figure 4). Thermokarst is a slow natural process that can be aggravated and accelerated by ground disturbances.

Retrogressive thaw flow slides occur in fine-grained, ice-rich soils, and result from the thawing and subsequent flow of the ice-rich soils. Failures occur on very gentle slopes, and over time can retrogress some distance back from the escarpment. The alignment was routed away from existing slides, old slide scars, and slopes with attributes that were judged to be susceptible to failure.

Pingos (Figure 5) are ice-cored hills formed by the hydrostatic pressure in wet areas underlain by ice-rich soils. They can be up to 50 m high, have a base of up to 600 m in diameter and can take centuries to form. Several large pingos are located near Tuktoyaktuk, west of the ITH near the Beaufort Sea coastline. Pingos are

Figure 3. Polygonal terrain.

Figure 4. Thermokarst terrain.

considered both cultural and heritage resources.

Embankment design and construction

To minimize thaw beneath the road embankment, the design included a minimum embankment height for each representative terrain type. The representative terrain types were established based on terrain mapping, geothermal analyses and engineering judgement.

Granular materials used for embankment fill were relatively scarce along the alignment. Surficial geology mapping identified potential borrow sites, then approximately 700 boreholes delineated and characterized the materials. The materials were categorized as sand with some gravel, to silty sand with a trace of gravel. These materials were excavated, hauled, placed and compacted in a frozen state on the frozen tundra during the winter months (Figure 6). The organic cover overlying the ice-rich soils, was left in place to act as a separator and a protective insulating layer. No cuts were made along the highway.

Because frozen soils cannot be compacted to the same density as unfrozen soils, specifications for material selection, placement and compaction were developed by establishing gradation specifications, maximum ice content, unfrozen moisture content and minimum compaction requirements. The embankment settlement, resulting from the compacted frozen soils thawing in the summer months, was estimated and incorporated into the design as an embankment overbuild.

A non-woven geotextile was placed beneath the embankment side slopes to separate the embankment fill from the underlying tundra, and to provide reinforcement to reduce the potential for lateral embankment spreading. Some thawing is expected where the embankment fill thins towards the side slopes, and the embankment was designed accordingly.

Efforts were taken to avoid the concentration of surface water flow and ponded water along the road embankment. Culverts were installed at all low points along the embankment to minimize ponding, and drainage ditches were not excavated.

Summary

On November 15, 2017, the Inuvik to Tuktoyaktuk Highway became the first Canadian highway entirely constructed on continuous permafrost terrain. The sensitive ice-rich soils along the alignment required careful embankment design and construction considerations. Preserving the existing permafrost condition to support the road embankment was critical in minimizing the risk of thermal degradation and associated thaw-settlement and instability of the embankment. To protect the permafrost, a 'fill-only' embankment design was employed, and construction took place during the winter months, placing frozen granular materials on the frozen tundra.

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Figure 5. Pingos.

Figure 6. Winter construction.

Women in Canadian Geotechnique

Andrea Lougheed (BGC Engineering Inc.) is a member of the CGS Heritage Committee and its Task Force on Women in Canadian Geotechnique. It this article, Andrea introduces some of the recent work of that Task Force. Heinrich Heinz, Chair CGS Heritage Committee.

Introduction

The geotechnical profession has historically been male-dominated and, until relatively recently, female representation has been minimal or non-existent. This imbalance was common in all STEM (science, technology, engineering and mathematics) fields, but has been gradually changing since the mid-1900s. In the Canadian geotechnical field, this change is reflected in the growing female enrollment at the undergraduate and graduate levels, and some universities are currently seeing gender equality in their geological programs. Geotechnical consulting firms are also seeing a growing number of female professionals. Anecdotally, in some firms, this is as high as 50% at the junior level, and 30% at intermediate and senior levels. Women, like men, are drawn to the geotechnical profession through their love of nature, and their desire to understand how the world works and to be a positive force for change.

Currently there are initiatives in Canada to increase gender diversity in the STEM fields; for example, Engineers Canada's "30 by 30" initiative to increase the percentage of female engineers to 30% by 2030. The percentage of female professional engineers in Canada has increased from 9.5% in 2008 to 12.8% in 2016. In 2016, the number of newly licensed female engineers increased to 17%.

Within the Canadian geotechnical community, we are also seeing more women. Female CGS members have increased from 9% to 12% between 2008 and 2017. Anecdotally, female delegates at recent CGS annual conference have been estimated to be roughly 20%. In 1999, Anne Poshmann and Jean Hutchinson became the first female CGS Executive Committee (EC) members (VP Financial and Division Representative, respectively). Since then, women have served in all CGS EC positions. Since 2013, women on the EC have ranged between 25% and 43%. This year, 22% of the executives of the CGS sections, and 25% of the CGS Section Directors, are women.

Although statistics indicate a growth in women in the Canadian geotechnical profession, their past involvement and contributions to the geotechnical community may have been overlooked and/or underappreciated. The CGS Heritage Committee has been working to identify and profile some of the first women in Canadian geotechnique. This furthers Anna Burwash's 1997 *Geotechnical News* article entitled "Breaking New Ground–Women in Geotechnical Engineering" (Commemorative Edition, Vol. 15, No. 4, p. 69-73, also on the CGS website at *http://www.cgs.ca/pdf/heritage/Geotech%20Eng%20in%20canada%20%20An%20historical%20review.pdf*). As part of the current Heritage Committee's initiative, twelve women were interviewed about their education, careers and other professional activities. A brief profile of four of these women, all who began their careers in the 1960s, follows. These four, and an additional eight women, will be further profiled at the 71st Canadian Geotechnical Conference in Edmonton (GeoEdmonton 2018) in September.

Anna Lankford Burwash

Anna Lankford Burwash

Anna first became acquainted with geotechnical engineering as an undergraduate in Civil Engineering at Carnegie Mellon University (B.Sc. 1968). She found geotechnical papers interesting to read and reassuringly practical, and was excited with the prospect of working with very heterogeneous materials like soil, rock, and muskeg. Anna was the only woman in her class and possibly only the third woman to receive a degree in Civil Engineering at Carnegie Mellon.

Following graduation, Anna moved to Canada and began research work with two professors at the University of New Brunswick and that led to her working at the Muskeg Research Institute in 1970. This was followed by consulting work with Geocon, in New Brunswick, and Hardy Associates, in Alberta. In 1980, Anna entered the management consulting field with her own company, A.L. Burwash Consulting.

Anna participated in several professional organizations over the years, including the CGS. She attended her first CGS conference in 1971, was the CGS Atlantic Region Director between 1973 and 1976, and founded the CGS Fredericton Section. Also in the 1970s, Anna served on the NRC Associate Committee on Geotechnical Research, and was the first female

Associate Editor of the *Canadian Geotechnical Journal*. Anna was the Chair of the Calgary Branch of the Engineering Institute of Canada in 1980 and Chair of the ASTM Subcommittee on Peats and Related Materials in 1987 and 1988. She became the first woman to chair an ASCE Executive Committee. In 1999, Anna was recognized by the ASCE for making "outstanding and unusual contributions towards the advancement of professional relationships between engineers in the US and Canada".

Dr. Suzanne Lacasse

Suzanne Lacasse.

Suzanne originally hails from Noranda in northern Québec, where she grew up in a family of civil engineers who would tour her around construction sites. This early influence led her to the field of civil and geotechnical engineering at École Polytechnique de Montréal where, in 1971, she was the only woman in her graduating class of 45. She later obtained her Master's (1973) and Doctorate (1976) from MIT, where there were only two women among the 50 graduate students.

Suzanne has worked in academia as a Lecturer at MIT, École Polytechnique and University of Oslo, and in industry for Ardaman & Associates, Exxon and Total in the US and Laboratorium voor Grondmechanica (LGM now Deltares) in the Netherlands. She is, perhaps, most well known as the Managing Director (1991-2011) of the Norwegian Geotechnical Institute (NGI), where she now serves as their Expert Adviser. Suzanne's career has provided her opportunities to work in countries all over the world.

Suzanne has continuously been involved in the CGS since 1970. In 1994, she gave the fall Cross-Country Lecture Tour. From 2003 to 2004, Suzanne served as CGS's first and, to date, only female President. She received the CGS's R.F. Legget Medal (2007) and the EIC's K.Y Lo Medal (1999) and John B. Stirling Medal (2009), respectively. For many of the awards Suzanne has received, she has been the first woman and only woman to receive them.

Her notable achievements outside of Canada are too numerous to list in their entirety. They include keynote lectures in 30 countries, including the Terzaghi (US 2001) and Rankine (UK 2015) Lectures. In 2015, the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) established the "Suzanne Lacasse Honorary Lecture" on "Engineering Practice of Risk Assessment and Management".

Gretchen Minning


Gretchen Minning.

Initially interested in history, Gretchen became interested in the history of the Earth while completing her undergraduate studies at Lawrence University in Wisconsin (1965). During her graduate studies at the University of Washington, in Seattle, she was the only female student. Following the completion of her Master's in 1967, Gretchen moved to Ottawa to work for the Geological Survey of Canada mapping the surficial geology of portions of Labrador and the Mackenzie Valley.

In 1973, Gretchen joined Northern Engineering Services Company Ltd. in Calgary and carried out terrain mapping, borrow investigations and other studies for a pipeline from Alaska to Alberta. Between 1977 and 1980, she worked for Hardy Associates in Calgary on geological studies mostly related to northern pipelines, transmission lines, oil spill contingency and dams. Since 1980, when Gretchen started her own consulting firm G.V.M. Geological Consultants, she has concentrated on increasing her clients' understanding of the geotechnical aspects of surficial geology. She may be the first woman in Canada to have established her own geotechnical consulting firm.

Gretchen has been involved with the Calgary Geotechnical Society since 1973. She was on the organizing committee for the 54th Canadian Geotechnical Conference in 2001. In 2018, she was the recipient of the Calgary Geotechnical Society Award.

Danielle Zaikoff

As with many women who become engineers, Danielle was interested in mathematics and science at a young age and was encouraged to pursue engineering by her father. It was during her time as a student in Civil Engineering at École Polytechnique de Montréal (B.Eng. 1967) and summer jobs that she was exposed to geotechnics. Danielle also received her Master's from École Polytechnique in 1972.

The focus of her entire career was related to hydroelectric development with Hydro-Québec. Danielle started in the Contract Department, because at the time women were not permitted

Danielle Zaikoff.

to conduct field work. She progressed from there to the Geology and Geotechnics, and Dam Behaviour departments to become Director of Central Engineering (1984), Director of Construction (1986), and then Director of Plant Engineering (1988). Danielle was the first female to become a Director in Hydro-Québec's history.

Danielle attended a number of CGS annual conferences in the early 1970s and was involved with the Association for Women in Science for a number of years. Also in the early 1970s, Danielle volunteered with the Ordre des Ingénieurs du Québec (OIQ), where she served as Secretary-Treasurer and Vice-President and then became its first female President in 1975. Three years later Danielle became the first female President of the Canadian Council of Professional Engineers (currently Engineers Canada). Following a long and illustrious career, Danielle retired in 2004 returning to her love of painting.

Closing remarks

There is some commonality in all the women profiled. They have focused on their technical competency, benefited from wonderful mentors, and have been involved in both the geotechnical and wider professional communities. Common pieces of advice they provided have been to concentrate on technical skills and professional judgement, to develop good working relationships and to take advantage of the opportunities that come along.

We encourage everyone to learn more about women's involvement and their contributions to the Canadian geotechnical profession. If you have further information or personal stories to share, please send them to the CGS Heritage Committee (*Heritage@cgs.ca*).

The future for women in the Canadian geotechnique looks very bright.

Acknowledgements

The author would like to thank the women who were interviewed as part of this initiative and their willingness to share their experience and to provide inspiration and mentorship to future generations of female geotechnical professionals. Melissa Ruel, Amy Rentz and Sarah Verwey helped interview some of the women. Ariane Locat, Frédérique Tremblay-Auger, Catherine Cloutier, Julie Therrien, Sandra Veillette, and Lilianne Landry-Paré assisted with the French translations of the posters for GeoEdmonton 2018.

The author would also like to thank Doug VanDine and Heinrich Heinz for their efforts and encouragement in this initiative. Their encouragement, and that of others, to get more women involved in the Canadian geotechnical community is greatly appreciated by several young women, the author included.

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Tailings management accounting
Should net present value be applied tailings management?

David Williams

Introduction

Large-scale mining projects are high cost. In order to facilitate the financing of new mining projects, the Net Present Value (NPV) accounting approach is applied, with a high Discount Factor of typically 6 to 10%, several times the inflation rate. At a 10% Discount Factor, a 10-year delay in expenditure is discounted by 61%. The NPV approach is extended to tailings disposal (as it is to all other mining and processing operations), resulting in the minimisation of short-term capital costs, with rehabilitation costs discounted by the same high Discount Factor. For tailings, an inexpensive, small surface tailings facility is typically initially constructed, to store tailings slurry delivered by robust and inexpensive centrifugal pumps and pipelines. While this produces initial cost savings, small storages fill rapidly, requiring frequent raises and further storages, which are also typically small, to limit upfront costs. This approach results in:

- Wet and soft tailings deposits, excessive stored water, and an ever-increasing tailings stored volume and footprint.
- An increased risk of tailings dam failure, since the tailings typically remain flowable.
- A blow out in operating costs to avoid capital costs, with inevitably increasing capital expenditure to meet the ever-increasing volume of tailings and water to be stored.
- Difficult and costly closure and rehabilitation, typically delayed until the end of the mine life when revenues have ceased, discouraging rehabilitation and leading to poor land use potential and ecological function.

While the use of NPV and an artificially high Discount Factor result in apparent cost savings in tailings management in the short-term, costs and cumulative, unintended detrimental impacts rise over time, with ever-increasing closure and rehabilitation risks and costs in the long-term. Larger initial tailings footprints may enable the optimal cycling of tailings disposal to improve tailings dewatering, density and shear strength, and subsequent rehabilitation.

Illustrative coal tailings example

Simple NPV analyses are applied to alternative management and closure approaches for coal tailings from open pit mining operations in the relatively flat terrain of the Eastern Australian Coalfields. A mine life of 20 years is assumed.

Tailings management options considered

The conventional approach to coal tailings disposal and storage in the Eastern Australian Coalfields is the pumping of the tailings as a slurry at about 25% solids by mass (gravimetric moisture content of about 300%, about 85% water by volume, and dry density of only about 0.30 t/m^3, for a typical specific gravity of about 1.80) using robust and inexpensive centrifugal pumps, to a surface tailings storage facility (TSF). The coal tailings are typically deposited in the surface TSF sub-aerially forming a beach, and undergoing hydraulic sorting according to particle size and specific gravity, settling, consolidation and desiccation of the exposed upper beach. Clay mineral-rich coal tailings, particularly those with even a small proportion of sodium Smectite, may not settle significantly from the input % solids of 25%, and will not produce clear supernatant water. Coal tailings containing no Smectite will typically settle to 50% solids (gravimetric moisture content of about 100%, about 65% water by volume, and dry density of about 0.65 t/m^3) and produce clear supernatant water for recycling to the plant. Such coal tailings may eventually consolidate under the self-weight of a high thickness of coal tailings to between 65% and 70% solids (gravimetric moisture content of between about 54% and 43%, between about 50% and 45% water by volume, and dry density of between about 0.90 t/m^3 and 1.00 t/m^3). Exposure of the surface to desiccation by the sun and wind may increase the dry density to about 0.83 t/m^3.

As completed pits become available, and the permitting of new surface TSFs takes increasingly lengthy timeframes and becomes increasingly difficult, completed pits may be used for tailings storage. The coal tailings are typically deposited in-pit at the same 25% solids by mass. The shape of the pit results in a very rapid rate of rise of tailings initially. This and the difficulty of recovering water from the pit, mean that the tailings may remain flooded and under-consolidated, rapidly filling the pit, mainly with water. This is partially overcome by thickening the coal tailings prior to in-pit disposal, although coal mineral-rich coal tailings have proven difficult to thicken.

A number of newer coal projects in Eastern Australia has adopted belt press filtering of the tailings, and the mixing of the output with coarse reject for disposal within the spoil piles. However, Smectite-rich coal tailings have proved difficult to filter, resulting in a wet mixture of tailings and coarse reject, and hence a wet co-disposed mixture within the spoil. A small number of coal mines in Eastern Australia has employed either on-off temporary surface tailings storage cells in which the tailings are desiccated and harvested periodically and dumped with coarse-grained wastes, or pressure plate filtration. The tailings management options considered are:

1. A series of surface TSFs.
2. An in-pit TSF.
3. On-off temporary surface tailings storage cells.
4. Pressure filtration and "dry" disposal of the tailings filter cake with coarse-grained wastes.
5. A surface TSF until a completed pit becomes available for tailings disposal.

NPV analysis of capital and operating costs

Figure 1 illustrates NPV capital and operating cost comparisons for Discount Factors of 2.5% (close to the Consumer Price Index), 5% and 10%, applied to the tailings management options considered. These comparisons do not include closure and rehabilitation costs.

The high costs of the series of surface TSFs would surprise many, but arise from the flat terrain of the Eastern Australian coalfields providing limited "free" valley storage for tailings and requiring an ever-increasing length of dam around the perimeter of a surface TSF. This limits the height of each TSF due to the excessive cost of dam raising and the ever-increasing length of perimeter dam required, forcing a new surface TSF to be constructed. An in-pit TSF is the least expensive option, but this assumes that a pit is available from the start, which is unlikely. The other three options attract similar capital and operating costs. The costs of on-off temporary tailings cells are dominated by high re-handling costs, although drying by the sun and wind is relatively robust, with high rainfall affecting less than 30 days per year on average in the Eastern Australian climate. The costs of pressure filtration are dominated by the high up-front cost of the equipment, which is the main reason why this option is often removed from consideration early in the selection process. Pressure filtration is also sensitive to the inevitably variable input stream, resulting in operational difficulties, particularly for clay mineral-rich coal tailings. The initial use of a surface TSF until a completed pit becomes available for tailings disposal appears to be marginally the best option.

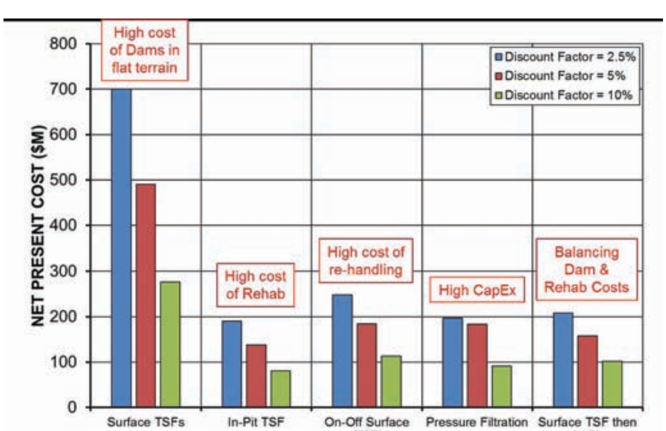

Figure 1. NPV comparisons of alternative tailings storage scenarios.

Including closure and rehabilitation costs

Figures 2 and 3 show, respectively, NPV comparisons at Discount Factors of 10% and 2.5%, for a series of surface TSFs, including operational and rehabilitation costs. Three surface TSFs are operated during the 20-year life of the coal mine, the first to year 7, the second from year 7 to year 15, and the last from year 15 to year 20. Rehabilitation of the TSFs is carried out progressively, the first in year 7, the second in year 15 and the last in year 20. A 10% Discount Factor obscures the cost of TSF rehabilitation, which is by far the major cost impost in undiscounted terms, while a more realistic 2.5% Discount Factor better reflects the real and substantial cost of rehabilitation. Leaving the rehabilitation of all three TSFs to the end of the mine life would reduce the heavily discounted cost of rehabilitation further, while likely to raise the actual cost.

Rehabilitation security deposit

New South Wales and Queensland Regulators require coal mine operators to assess and submit a Security Deposit against future mine site rehabilitation. Both the New South Wales Rehabilitation Cost Estimation Tool (www.resourcesandenergy.nsw.gov.au/miners-and-explorers/rules-and-forms/pgf/environmental-guidelines), and the Queensland Mining Financial Assurance Calculator (www.business.qld.gov.au/running-business/environment/licences-permits/rehabilitation/security-deposit) provide the same indicative costs for reshaping, capping/sealing tailings:

- AUD170 000/ha for tailings likely to present considerable difficulties due to reactive and/or soft tailings.

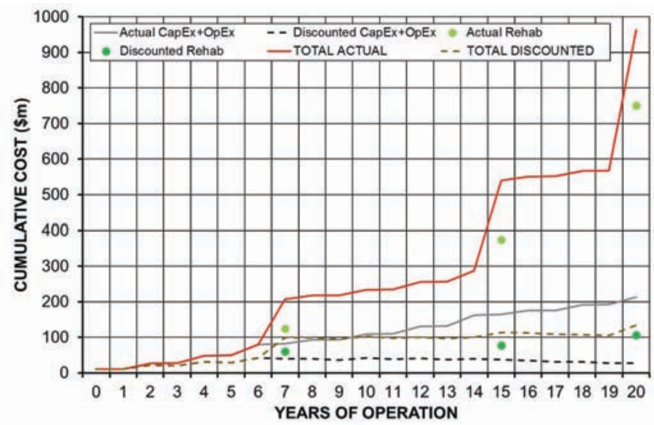

Figure 2. NPV comparisons at a Discount Factor of 10%, for a series of surface TSFs, including operational and rehabilitation costs.

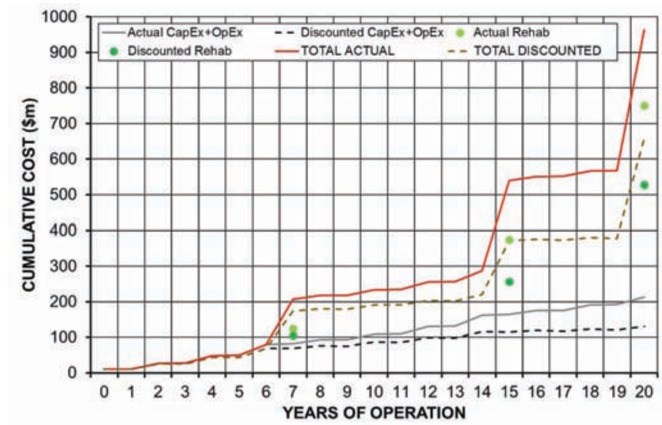

Figure 3. NPV comparisons at a Discount Factor of 2.5%, for a series of surface TSFs, including operational and rehabilitation costs.

- AUD108 000/ha for tailings likely to present moderate difficulties due to reactive and/or soft tailings.
- AUD81 000/ha for benign and strong tailings.

In addition, indicative unit costs are provided for land preparation and revegetation of AUD4 000 to 5 000/ha, plus maintenance of rehabilitated tailings of AUD300 to 40 000/ha, increasing with decreasing rehabilitation performance from successful rehabilitation to total rehabilitation failure. Hence, the total Security Deposit ranges from AUD85 300 to 215 000/ha, while the actual rehabilitation costs could be far lower if undertaken progressively and making use of suitable mine waste materials as they become available, presenting a large potential for cost savings. The Security Deposit is typically covered in the form of a Bank Guarantee, which is based on a benchmark such as the London Interbank Offered Rate (LIBOR), plus a premium of around 0.3% per annum of its value, and its duration, and would be expected to be 1.5 to 3% per annum of the Security Deposit. While this rate is of a similar order to the inflation rate, the Bank Guarantee and budget to cover the Security Deposit tie up funds that could be used more productively.

The cost of a Bank Guarantee could range from about AUD1 300 to 6 500/ha per annum, which appears to be small compared with the actual cost of rehabilitation.

The actual cost of rehabilitating coal tailings will depend on the difficulties presented by the tailings and the storage, and the availability and cost of suitable capping materials. It could take advantage of reduced costs for material supply and haulage during operations, to be as low as perhaps AUD50 000/ha, or lower. The cost of a Bank Guarantee could amount to AUD50 000/ha over 7.5 to 40 years, not accounting for inflation. Effectively encapsulating potentially contaminating coal tailings, accommodating or improving their poor bearing capacity, and progressive rehabilitation using capping materials available during operations, will translate to substantial cost savings and greater certainty about the rehabilitation of coal tailings.

Conclusions

While high costs of large-scale mining projects may necessitate NPV with a high Discount Factor to secure financing, it is best not applied to tailings operations and closure since it:

- Increases the risk of tailings dam failures.
- Adds to the increasing threat to the mining industry's financial and social licence to operate.
- Entrains excessive process water; storing water rather than solids and taking up more volume.
- Leads to wet and soft tailings deposits.
- Potentially leads to unintended cumulative impacts that are difficult and expensive to rectify.
- Leads to difficult and high cost tailings rehabilitation.
- Discourages tailings rehabilitation.
- Limits post-closure land use and ecological function of tailings storages.
- Distorts and increases actual Life-of-Mine costs.

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Paolo Gazzarrini

Overture

51st episode of the Grout Line after missing the June issue due to technical/space problems.

To catch up, the first news is a sad news, as Don W. Deere (son of Don U. Deere- *don.deere@deereault.com*) wrote to me.

Dr. Don U. Deere at his 90th birthday.

Dr. Don U. Deere passed away early this year at the age of 95. Don was world-renowned in the fields of engineering geology and rock mechanics. As a professor at the University of Illinois from 1955 to 1972, he developed the Rock Quality Designation (RQD), a common standard used in rock core logging.

Dr. Don U. Deere in the field.

He became a full- time international consultant in tunnels and dam foundations in 1973 where his interest in grouting peaked. He served on multiple Board of Consultants throughout South America with the majority of the projects in Brazil which was building numerous hydroelectric projects in the 1970s through the 1990s. He met Dr. Giovanni Lombardi of Switzerland during this period and they became close friends and colleagues. It was during their collaboration together on various Board of Consultants assignments that the Grout Intensity Number or GIN grouting method was developed and successfully applied on many projects.

Dr. Deere will be missed for his innovative thinking, his ability to combine the disciplines of geology and civil engineering to solve construction problems, and his unbridled enthusiasm to teach and pass his experience and knowledge on to all he worked with.

Over the period of less than 1 year, the two designers of the GIN (Grouting Intensity Number) method of grouting, left us. If we believe in this grouting method it will be our duty to try to continue their legacy.

Dr. Don U. Deere in the field.

For anyone interested in a complete biography of Dr. Don U. Deere, here is a link https://tunnelingonline.com/memoriam-don-u-deere/

The second news is related to the annual Grouting Fundamentals Course (the original) held in February. A short summary prepared by Prof. Scott Kieffer, course director.

The 39th annual short course on **Grouting Fundamentals & Current Practice** was hosted by The University of Texas at Austin's Cockrell School of Engineering from February 12-16, 2018. The event was attended by professionals worldwide to learn the latest and best in the field of geotechnical grouting. Since 1979 this unique course on grouting materials, methods and applications has educated over 2,000 professionals and filled a wide gap in traditional university education. Although theory and calculations are an integral part of competent grouting work, practical field experience is essential for the success of any grouting job. An incredible breadth and depth of subject matter was covered by a renowned course faculty that included experts from seven countries. The 2018 course included 70 delegates representing engineering design firms, specialty geotechnical contractors, hyropower facility owners, equipment manufacturers and material suppliers. As is common, the majority of delegates were from throughout the US and Canada, with significant overseas attendance based on major upcoming geotechnical construction works. The recent course included such delegates from Australia, Albania, Bolivia, Uganda, and throughout Europe.

Grouting fundamentals & current prctice short course.

The traditional ½ day Field Demonstration is an integral part of the course that facilitates direct hands-on learning. The Field Demo included high shear mixing, QC testing of fluid grout, slab jacking, penetration of microfine cements, tube-a-manchette grouting, methods for nondestructive quantification of ground improvement, along with a broad spectrum of grout materials (cementitious, chemical, and cellular).

The 2019 course will again be hosted by UT Austin. For course details visit: *www.groutingfundamentals.com*

For additional information please contact Prof. Scott Kieffer, Course Director, at *kieffer@tugraz.at*

In conclusion, the article of this issue whch is an unusual application of HM grouting in a "dried, sinking" fountain in Philadelphia, PA. Authors of the article are Mike Miluski PE-Vice President at CGS-Compaction Grouting Services, Wallingford, PA (mmiluski@cgsinc.net) and Brian M. Fraley, Owner of Fraley Construction Marketing, Morgantown, PA (bmfraley@fraleysolutions.com).

High mobility grouting keeps historic fountain from sinking

Portions of the Catholic Total Abstinence Fountain in Fairmount Park were in "imminent danger", according to a "Restoration Services" Request for Proposals (RFP) issued by the City of Philadelphia in August 2014. Open voids in the foundation were causing ongoing settlement.

The owner is the City of Philadelphia, although the Planning, Preservation, and Property Management Division of Philadelphia Parks & Recreation procured and managed the project. A design-build grouting approach was proposed to the City.

A fountain of historical significance

The fountain was unveiled in 1876 as an ornamental drinking fountain for the Centennial International Exhibition, which celebrated the signing of the Declaration of Independence in Philadelphia. Its creation was commissioned by the Catholic Total Abstinence Union of America, an Irish temperance organization that advocated for total abstinence from alcohol. Ironically, the fountain ran dry decades ago.

The now-defunct fountain features a 100-foot-wide granite base with three steps in the shape of a Maltese Cross. The centerpiece – enclosed by a 40-foot-diameter basin – is a 15-foot Moses statue perched on an igloo-shaped marble mound. Four subsidiary statues rise from granite pedestals at the tips of each arm of the cross, including Archbishop John Carroll, Charles Carroll of Carrollton, Father Theobald Mathew, and Commodore John Barry.

Natural and man-made damage inflictors

The City of Philadelphia's RFP called attention to three "high priority structural areas". It was noted that Moses, Father Mathew, and the steps surrounding the fountain had been documented as public hazards. The long-term effects of water infiltration had set in, eroding mortar joints and

Moses in the front.

causing some stones to jut out. Furthermore, the stone base supporting the 16-ton Moses statue was in danger of collapsing. The Father Matthew statue had been struck by lightning in 1910 and repaired with an iron and metal pin anchor system, which had succumbed to corrosion. The city considered it the most threatened of the statues.

A preliminary comment during the initial site visit was: "The fountain is in pretty bad shape" and two main goals were identified. One was to inject grout beneath the Moses statue's stone base. The second was to pump grout into various points to support the granite steps surrounding the marble fountain and four satellite statues.

The monument's location in the center of a traffic circle further complicated matters. It was obvious that the fountain had been damaged by errant vehicles. There were, in fact, several such incidents during the repairs, which prompted the erection of jersey barriers around the perimeter.

The gist of the project was to fill the void spaces in the statue to stop settlement and rehabilitate the affected structures and the logical solution was to use high-mobility grout under low pressure – 25 psi or less.

A pattern of drilled holes was chosen to try to intercept the spider web of interconnected voids.

Masonry and grouting go hand in hand

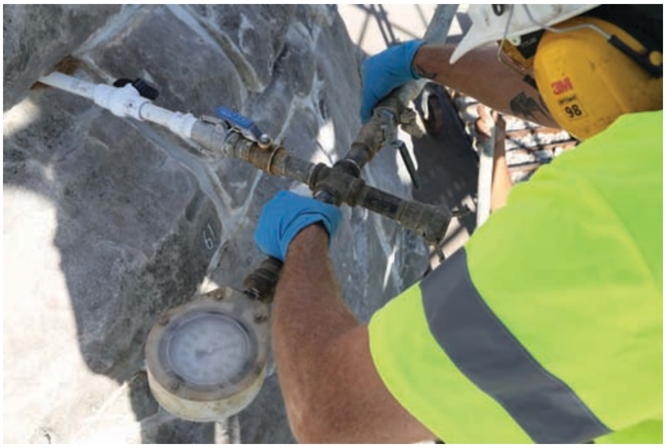
Masonry and grouting contractors worked closely since their respective scopes were closely interwoven. Daily logistical coordination was required for tasks such as moving and resetting stones; pointing stone joints; coordinating access to the scaffolding; providing access for grouting ports; and protecting the fountain throughout the restoration. Making sure grouting ports were available was key to avoiding downtime. The grouting contractor worked continuously with the mason to coordinate their installation. The mason would also have to point the stone joints prior to injecting grout into Moses' stone base.

Grout mix

Instead of using pre-confectioned grout mixes, a custom mix design was proposed, based on Type 1 Portland Cement, Undensified Silica Fume, water, a stabilization and shrink reduction admixture, and a water reducer. The final composition to produce an 8 CF batch was 6- 94 lb Type I Portland Cement, 1- 50 lb bag of Undensified Silica Fume, ½ gallon of water reducer and 33 gallons of water.

Grout Fairmount Fountain.

Grout Fairmount Fountain.



Grout Fairmount Fountain.

The final mix had a UCS of 9,000 PSI at 28 days.

The custom mix design resulted in significant savings as compared to using pre-confectioned grout mixes.

Mixing and injecting the grout

The grout mix was prepared and injected with a ChemGrout CG-600 Colloidal Mixing Grout Plant. The plant's 13-cubic-foot colloidal mixer and agitation tank and positive displacement piston pump allowed workers to mix material and inject at the pre-existing points. A telehandler was used to deliver cement pallets to the CG-600 to keep the grout flowing. Much like concrete, the grout had to be injected immediately after it was mixed.

A total of 460 cubic feet of grout was prepared and injected into the fountain.

Drilling or cutting through the granite and marble was not permitted, so finding suitable existing openings for injection ports was key. In those areas with smaller holes, the team altered the mix design, used smaller diameter injection ports, and adjusted the flow to achieve adequate coverage with the lower strength mix. It was also important to consult with the owner and design team to make sure this revised approach was acceptable to support the restoration effort. The more flowable mix was generally 1-94 lbs of cement, 5 gallons of water, water reducing and flow enhancement admixtures, as needed.

The injection locations were predetermined; however, there were areas such as the granite blocks from the top row of stairs that had to be temporarily removed to accommodate injection ports.

The crew had to stay aware of changing conditions and respond as needed. This meant observing the joint for moisture and watching for unwanted structural movement. The finished joints were then plugged with oakum, burlap, and a stick.

The historic nature of the fountain required the grouting contractor to exercise extreme caution to prevent damage. The hardest thing was to use the PVC pipe and not get the primer or glue on the statue.

Grout Fairmount Fountain.

Two weeks to correct a 141-year old problem

Despite the complexity of the process, the grouting work was completed on schedule in two weeks during August, October, and November of 2016 with logistical challenges. Perhaps even more fascinating is the fact that the grouting helped to correct problems that unfolded over 141 years in less than 14 days. All parties are in agreement when it comes to hoping that the City of Philadelphia will not be issuing another RFP until at least 2158!

As usual I conclude with the same request, asking you to send me your grouting comments or grouting stories or case histories. My coordinates remain:

Paolo Gazzarrini, *paolo@paologaz.com , paologaz@shaw.ca or paolo@groutline.com.*

Ciao! Cheers!

Richard Guthrie, Editor

Hola amigos! Field season finds me in the high-altitude environments of Indonesia, and now Peru, today in Moquega, exploring geohazards related to steep unending slopes, wind blown soils and flash floods. I am thinking, as always, about hazards and risk, what is acceptable and what is not, and how the hazards geoscientists and engineers address compare to the more frequent hazards that affect everyday living for much of the world (access to water, job security, safety etc…).

In Canada, we appear to have established a risk threshold that is variously 1:100 – 1:200 (basic flood design), 1:475 (damaging events), 1:2,500 (flood proofing for subdivisions), and 1:10,000 (catastrophic life threatening events). This quarter, Mathias Jakob, Pierre Friele, Michael Porter, Oldrich Hungr and Scott McDougal give the question of landslide risk (and by inference risk in general) a thoughtful treatment and make specific recommendations using British Columbia as their testing ground. I encourage you to read their article.

Geohazards 7 was a success by all accounts. It was well attended from the beginning to the end and full of excellent presentations demonstrating innovative research and understanding of earth surface processes. The conference was interspersed with impactful observations from the town of Canmore, members of which were so very impacted by the mountain streams flooding in 2013. I came away feeling like Canada is in good hands, advancing in step with technology, and genuinely contributing to this important field. I'll provide a more detailed summary of the conference in Q4.

In the meantime, If you have a paper or project related to Geohazards that you think would be interesting to GN readers, please send me note at *Richard.guthrie@stantec.com.*

Until then,

Rick

Should BC plan for the 1:10,000 probability landslide event?

Matthias Jakob, P.Geo., Pierre Friele, P.Geo., Michael Porter, P.Eng.,

Oldrich Hungr, P.Eng./P.Geo., Scott McDougall, P.Eng.

Dedicated to our friend and teacher:
Professor Dr. Oldrich Hungr
who passed away on August 10, 2017

In British Columbia, geohazard risk management in general, and landslide risk management specifically, is becoming more pressing as development continues to encroach into mountainous areas and as hydroclimatic extremes are projected to increase in frequency and magnitude.

Landslide risk management has a long history in BC and, while the province does not suffer many landslide-related fatalities compared to other causes of involuntary premature death, the economic losses are substantial (Hungr, 2004). At this time, guidance exists for practitioners and regulators to manage landslide risk (e.g. EGBC, 2010). Hazard and risk assessments require input in the form of a landslide frequency-magnitude relationship or estimates of the probability of different landslide scenarios occurring. As with all geophysical phenomena, the higher the magnitude and intensity, the rarer they will be. For example, a Class V hurricane will occur at a much lower frequency than a Class III hurricane, a Richter scale 8 earthquake at a much lower frequency than a Richter scale 6 earthquake, and so on. The same principle applies to landslides.

A document titled: Subdivision Preliminary Layout Review – Natural Hazard Risk (MoTI, 2015) stipulates that up to the 1:10,000-year event should be integrated in landslide hazard or risk assessments in B.C.. The 1:10,000-year event was also considered in an expert panel review for the Cheekeye River development (Cheekye Review Panel #2, 2015) and in a paper by Cave (1992/1993). This article examines the associated challenges.

Most of British Columbia was covered by glaciers during the last ice age that eroded or obliterated the evidence of most pre-glacial landslides. Consequently, most recognizable landslide source areas and deposits are less than about 10,000 to 11,000 years old. For recurrent landslide processes such as debris flows or rockfalls, various techniques exist to characterize their frequency and magnitude. The estimation precision will be a function of many variables, such as the physical evidence available to decipher past events, the preservation and stratigraphic complexity of the deposits, and the practicality of accessing the data archive. These issues govern the types of methods available and the cost of applying some or all of such methods and to what detail. With significant investment, it is sometimes possible to estimate a statistically-based frequency-magnitude relation for events that have occurred for some period since deglaciation. In most instances, however, regional landslide inventories, slope stability analyses, assessments of current and anticipated site conditions, statistical methods and/or other inputs are combined with professional judgement to estimate landslide frequency and attendant magnitude, mobility, and intensity.

Various documents exist to guide the hazard threshold that should be considered in geohazard safety analysis (MoTI, 2015; EGBC, 2010, 2012). In BC, guidance ranges from the 1:200-year event for floods, the 1:300-year event for snow avalanches and up to a 1:10,000-year event for landslides. The reason for this sliding scale may be attributed to differences in the perceived rate of change in the destructiveness and lethal potential of a given geohazard with changes in probability.

With respect to landslides, according to provincial guidance (MoTI, 2015), a life-threating event ought to consider up to the 1:10,000-year event. This threshold was first referenced in work by Dr. Peter Cave (1993) and has been followed by at least one regional district in BC. The 1:10,000-year threshold is now also stipulated in a Ministry of Transportation and Infrastructure (MoTI) brief (2015) for its subdivision approval officers. To determine whether such an event has occurred, or to estimate the characteristics of a future event with this probability of occurrence, a gamut of absolute dating methods and various approaches to reconstitute and/or extrapolate event magnitude must be employed. However, the practitioner is invariably confronted with trying to estimate the magnitude (volume) and intensity (impact force) of an event for which there may not be any historical precedent, or it may not be practical to recover evidence of such an event in the field.

One of the fundamental issues with the 1:10,000-year event lies in the accuracy of its estimate. The accuracy and precision of estimating the magnitude of a landslide is proportional to its return period: The longer, the more uncertain, to the point where the error bars (judgement or statistically-based) are too large to be credible.

Another statistical issue emerges from the fact that landslide-generating mechanisms are not self-similar over a wide range of frequency-magnitude. The processes generating a 1:100-year debris flow, may be very different from those generating a 1:1000-year or 1:10,000-year debris flow, hence each perceived process type deserves its own frequency-magnitude relationship.

Assuming the data from past landslide events exists or can be reconstructed, one school of thought promotes only relying on data to assign event frequencies, and dismisses statistical wizardry to extrapolate, interpolate or impute data. This is reasonable only (a) for cases that are characterized by long and continuous records, (b) when there is a thorough understanding of the geomorphic processes and engineering geology and (c) when it can be reasonably assumed that the processes and process rates that generated the record have been constant and will prevail in the future. Unfortunately, these prerequisites are hardly ever met in BC or elsewhere.

Statistical analysis and extrapolation of known age and size pairs over a limited period can yield variable outcomes depending on the chosen distribution and the knowledge of the practitioner of the engineering geology and geomorphology of a slope or basin, which may limit the maximum credible event volume. This is especially the case when extrapolating to the 1:10,000-year event using only a few hundred years of record reconstructed.

Problems with geomorphic reconstruction invariably arise. For example, most valley bottom alluvial fan settings in settled parts of the province have been logged, limiting the use of dendrochronological methods for frequency analysis. Moreover, hundreds of developed fans are along marine or lake shorelines where much of the fan is below water level, which precludes test trenching and sampling organic materials for radiocarbon dating. Methods are available to estimate sediment yield from the watershed and channels, but it is hugely challenging to estimate the frequency, magnitude and intensity of a landslide triggered, for example, by a strong earthquake during the wet season, an event that, in coastal BC, might have a greater than 1:10,000-year probability.

A comprehensive geoscientific treatment of each such case can be rather costly, though perhaps affordable for large-scale developments, but the resultant uncertainty still may yield a vague "best estimate" of the lowest probability events that are to be considered in a risk assessment, and this uncertainty is typically unquantifiable.

Another issue is the problem of non-stationarity. In flood hazard analysis, decadal cyclic climate drivers may create non-stationarity, while in landslide analysis, centuries to millennia-scale oscillations arise from climate shifts or sudden morphologic watershed changes. Superimposed on these varying climate patterns is a millennial scale pattern of landscape readjustment following the demise of Pleistocene glaciers, the so-called paraglacial period. This period was characterized by an early Holocene sediment pulse followed by a rapid decline in sediment yield to "normal" yields in the mid to late Holocene. Thus, even in cases where radiocarbon dating allowed reconstruction of landslides back to the early Holocene era (~ 11,000 to 8,000 years ago), the applicability of the data to estimate the probabilities of future events could be suspect. Juxtaposed is the complication of including future climate change, which may eventually create event magnitudes and frequencies that plot outside the range of reconstituted paleo-records. Statistical treatment of the data series ignoring these trends would then be flawed and likely result in erroneous estimates of future events. The issue of non-stationarity in the rate of geomorphic processes including landslides is illustrated in Figure 1.

Finally, not all landslide processes are spatially recurrent. Rock avalanches

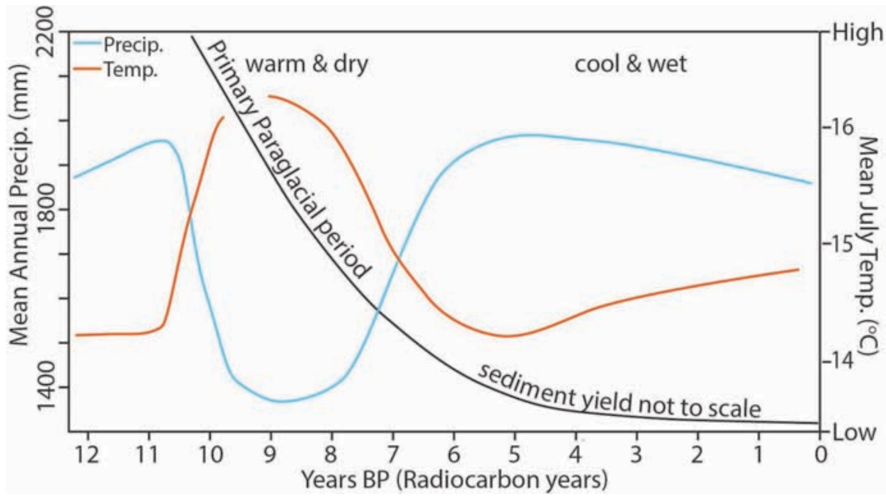


Figure 1. Non-stationarity of geomorphic processes due to the paraglacial pulse with reconstructed Holocene mean annual temperature and precipitation trends.
Image compiled after Mathewes and Heusser 1981 and Church and Ryder 1972.

rarely occur more than once in exactly the same location because source area depletion often precludes reoccurrence (Cruden and Hu, 1993). Methods are emerging to approximate rock avalanche probability based on regional inventories (Hantz et al. 2003; Catani et al. 2016). However, application of such methods will result in a broad range of estimated rock avalanche probability. If a rock avalanche is known to have occurred within the Holocene on a nearby slope that is similar in other respects to the slope being assessed, the estimated event probability range will often encompass the landmark 1:10,000-year event. This creates a conundrum: If the probability estimate is greater than 1:10,000, it would mean integration into risk assessments that may show that existing and/or future development is at unacceptable risk. Given that rock avalanches are unmitigatable in most instances at any reasonable cost, this can create a substantial political problem for the local government involved unless there is a basis for relying upon long-term monitoring programs. If, however, the probability estimate is lower than 1;10,000, development may be approvable without conditions according to hazard acceptance criteria that are currently in use. This can lead to progressive population growth in the area below a credible and potentially lethal landslide hazard, thus leading to conditions with ever increasing risk. In this context, it is of interest to compare BC practice to European Nations and Japan, who consider landslide return periods up to 300 years and rarely up to 1,000 years (Hong Kong) in hazard or risk assessments and mitigation design.

Given the tremendous uncertainty in estimating the characteristics of very low probability landslide events, and conservativism with respect to explicitly considering a much larger range of annual probabilities compared to other nations with much longer experience in managing geohazard risks, one wonders as to the origins of the 1:10,000-year landslide event guidance.

The 1:10,000-year event likely has its roots in an interpretation of the historic 1973 decision by Judge Thomas Berger with regard to a subdivision proposed in the Cheakamus River valley downstream of the Garibaldi Lake Volcanic Barrier. A second phase subdivision consisting of 126 lots on Rubble Creek fan had been planned by Cleveland Holdings Ltd. The senior approving officer for the Province, Mr. Elston, refused to allow plan deposition, and thus no title was conveyed to the subdivision, because he argued that the development of the subdivision would be against the public interest. Mr. Elston's decision rested on the potential of a catastrophic landslide originating at the Barrier to reach the development. An appeal was launched by Cleveland Holdings against this decision. Judge Berger presided the proceedings and made some key conclusions:

"Dr. Mathews and Mr. Naismith both calculate the risk of a [catastrophic] slide on a time scale of thousands of years. They say there is a probability of a slide at the Barrier in the next 10,000 years. It may occur next year, it may occur in a thousand years, it may occur in 10,000 years. Yet for both of them the risk is real enough that neither would want to live in the subdivision. The risk is one they would prefer to avoid."

In his decision, Judge Berger followed the logic of a risk analysis. He carefully examined the meaning of probability and identified that the hazard and risk is quantifiable and real. His final judgement, therefore, may constitute the first risk-based court decision with regard to landslide hazards in British Columbia.

This case, later supported by the Garibaldi Advisory Panel (1978), demonstrated the reluctance of the judge to accept a risk, which at the time was poorly quantified. Given that a catastrophic failure had occurred in the past 120 years, he was not willing to allow development to proceed.

This decision is key in the development of the 1:10,000-year probability or return period "standard" that has been propagated by Cave's (1993) work and has since been manifested in the Guidelines for Subdivision Approval Officers (MoTI 2015) as well as criteria that are being used to this day by the Fraser Valley Regional District in managing their geohazards.

Notably, however, Judge Berger's decision does not state explicitly that the 1:10,000-year event should be the target landslide probability or return period at which subdivisions are not to be approved. Rather, by analogy to the post glacial, Holocene Epoch, he was referencing a 10,000-year sample frame.

EGBC (2012) recognized the difficulty in reliably estimating the 1:10,000-year event for debris flows, and oriented itself on the existing national seismic code, which stipulates the use of an approximately 1:2,500-year event in building design. The underlying logic is that buildings designed to withstand ground motion accelerations commensurate with a 1:2,500-year earthquake would allow safe building exit, while a 1:10,000-year event may not. Implicit is the recognition that building design for a 1:10,000-year event may be cost prohibitive and that some level of unquantified residual risk is therefore tolerable. For landslide hazard and risk assessment and mitigation design, the 1:2,500-year event is still a threshold beyond those typically used in international practice for landslides.

In comparison, the EGBC Guidelines for Legislated Flood Assessments in a Changing Climate in BC (2012) classify assessments by the number of buildings proposed within a subdivision and suggest variable return periods up to the 1:2,500-year event be considered for flood hazard assessments and mitigation design.

In contrast, the Canadian Dam Association (CDA) and similar associations around the world classify dams according to their potential consequences of failure, and recommended that assessment and design criteria vary accordingly. For example, CDA classifies dams and assigns annual exceedance probabilities for earthquakes and floods for consideration and consultation in a risk-informed design and management considering up to the 1:10,000-year event where dam failure could result in "notionally more than 100 expected fatalities".

Proposed changes

This article highlights some inconsistencies in how natural hazards are being addressed through existing guidance and regulations. The following points attempt to provide improvements to the present situation, though the authors cannot claim to provide lasting solutions that may require site-specific stakeholder engagement.

- The approach of natural hazard risk management requires homogenization in BC. This does not imply application of the same range of frequencies for each geohazard, but a recognition of scientifically defensible reconstructions and statistically valid extrapolations or projections. This includes recognition of the highly non-stationary paraglacial decline in geomorphic activity during the Holocene.
- Competing guidelines should be either amended or abandoned. The key is to create a single broad consensus document applicable by all ministries, local governments and industries which ought to undergo detailed review by practitioners, academics and regulators alike, and which would be subject to episodic review, refinements and updates.
- The range of hazard frequency should be hinged to the level of proposed development density. This is in line with the notion of group- or societal risk. Very rare events can and will lead to fatalities. Society is willing to assume some risk for the perceived benefits of living in a desirable area. All future updates and refinements of EGBC landslide guidelines should include guidance on landslide safety criteria for landslide types other than only debris flows and debris floods.
- Specifically, for locations with a credible catastrophic landslide hazard the use of Quantitative Risk

Assessments (QRAs) should be promoted that include the spectrum of probabilities for existing and future development. A QRA will then allow a risk-based development decision without being attached to a single frequency or probability threshold.

- The Land Title Act and Community Charter both specify that consultants need to specify "the land may be used safely for the use intended". Such formalism in absence of a definition of "safety" should be replaced by quantifying risk for a development and then its comparison to tolerable or acceptable risk levels defined and adopted by government. We understand and welcome that the BC government is working towards such solution as conferring this critical risk tolerance decision to each municipal or regional government places a substantial burden on small governments who have limited human and monetary resources to develop and justify such criteria.
- In light of budget limitations that may prevent mitigation of existing developments against the entire spectrum of geohazard scenarios, geotechnical monitoring and warning systems should be considered as an alternative to manage residual landslide risk. This is especially true for potentially catastrophic landslides that may prove to be unmitigatable. Monitoring and warning systems may be useful to reduce risk to loss of life for existing development, but they should not encourage new development in hazardous areas because of in-perpetuity monitoring and maintenance requirements. While potentially expensive in installation and maintenance, their redundancies and sophistication can be adjusted to the degree of landslide activity observed.

The above recommendations can only be devoted meaningfully to the benefit of society if accompanied with systematic inventories of landslide geohazards and at least qualitative risk-based hazard prioritization. This should allow the identification of those areas requiring more detailed study and eventual mitigation. Guided by the goal of improving landslide risk management in BC, and striving to reduce catastrophic losses by practicable means, the authors call on provincial regulators to consider the suggestions outlined above.

Acknowledgements

We thank **Doug VanDine** and **Gord Hunter** for their thoughtful comments on a draft of this contribution.

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