THE MANY SIDES OF ROBERT F. LEGGET

Canadian Civil Engineer, Geologist and Historian

by Doug VanDine

August 2020

Based, in part, on

Geotechnique in Canada; a Personal Memoir
an unpublished manuscript by Robert F. Legget, 1983

Dedicated to Michael Bozozuk (1929-2020)

Long-time colleague and good friend of Robert Legget

Major contributor in various ways to
the Canadian Geotechnical Society,
the Canadian Foundation for Geotechnique and
the Engineering Institute of Canada

Cover photo: The two sides of the multi-faceted “Robert F. Legget Medal” that is presented annually by the Canadian Geotechnical Society and funded by the Canadian Foundation for Geotechnique. The medal was designed by Michael Bozozuk (photo source Canadian Foundation for Geotechnique).

Dr. Robert Ferguson Legget (1904-1994). Photo taken in his study at 531 Echo Drive, Ottawa, ON, associated with his receiving the 1989 Royal Bank Award (photo source Michel W. St-Louis)

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continued…

[A] International Conference on Soil Mechanics and Foundation Engineering, held at Harvard University, Cambridge, MA, June 22-26, 1936. With subsequent conferences, this became known as the first conference.

[B] The Associate Committee on Soil and Snow Mechanics of the National Research Council. It was renamed the Associate Committee on Geotechnical Research in 1965.

FOREWORD

Dr. Robert F. Legget gave a presentation to the Edmonton geotechnical group in the early 1980s that I attended as a University of Alberta graduate student. My memory is vague on the details of the talk, but I remember the man well: wearing a dark blazer featuring the coat of arms of his *alma mater*, speaking clearly without any slides and pointing to the wall behind him to guide our imagination. He held me and the rest of his audience captive and made an impression on many of us.

Years passed and in October of 1997 I attended my first Canadian Geotechnical Conference. It was the 50th "Golden Jubilee" conference held in Ottawa. A highlight for me was when many of us walked from the Chateau Laurier to a location beside the Rideau Canal for the unveiling of the Legget Memorial Monument. One memory of that ceremony that stands out is my learning that the concrete in the monument contained pieces of rock contributed by Legget's many friends from all over the world. Those pieces ranged from foundations of dams to pieces of rock that had been transported by an avalanche. The significance of this tribute, in a way both geological and human, still resonates with me.

Over the years, I gained additional insights into Legget's life and his many contributions to geotechnique and engineering history in Canada. After reading Doug VanDine's *The Many Sides of Robert F. Legget*, however, it became obvious how incomplete my knowledge of the man was. Using Legget's 1983 memoir as a starting point and with additional material obtained through dedicated research, Doug brings us the most complete account of Legget's life and career to date. From mostly unpublished documents in several archives, correspondence with sources in Canada and the UK, and memories from selected individuals, Doug answers many of the questions and fills in many of the gaps in Legget's memoir. Doug's added chapters, together with his many annotations, and the photographs he has found, bring to life several notable people, places and projects, in addition to his main character.

This book describes Legget's life and contributions thoroughly and portrays the early days of geotechnique in Canada as he saw it. It highlights many of the qualities of Legget: his exceptional work ethic, his leadership and foresight, his ability to make and keep friends and his dedicated mentorship of young professionals. Legget authored, co-authored and edited more than 500 publications on a variety of topics—without the help of technologies we now take for granted and at a time when the pressure and financial incentives to be published were far less. I believe this to be illustrative of a man determined to document his experiences and thoughts for the benefit of others, a practice he continued right up to the end of his life.

As noted in connection with Legget's appointment to the Order of Canada in 1967, he was someone who "enriched the lives of others and made a difference to the country." He was one of the giants in the geotechnical field on whose shoulders we stand.

On behalf of the Canadian Geotechnical Society Heritage Committee, I thank Doug for this wonderful description of Robert Legget. Doug's book provides us insights into the roots, relationships and life work of a man who helped Canada build its reputation as a leader in geotechnique, and a man who rightly deserves to be considered one the "Fathers of Canadian Geotechnique."

Heinrich Heinz, Canmore, AB
Chair, Canadian Geotechnical Society Heritage Committee,
July 2020

Chapter 1: INTRODUCTION

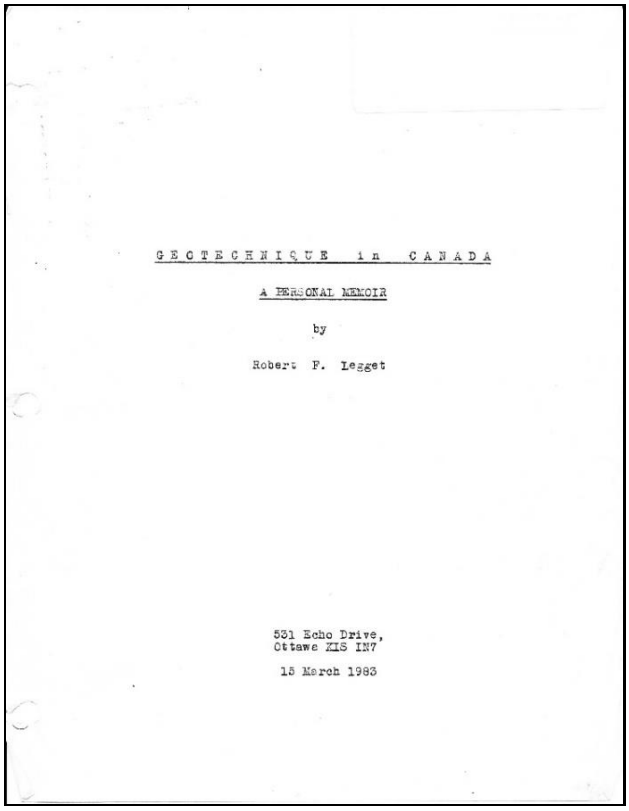
Most Canadians will not know the name of Robert Ferguson Legget, but all our lives have been enriched by this man and his work. Some who live in the Ottawa area may know his name because he lived and worked there for most of his career and wrote about the area. Others with an interest in the history of canals, railways, engineering or geology may also know him through his books and publications. Those associated with the geotechnical profession in Canada and the national building and fire codes of Canada should know his name because of the tremendous contributions he made to their fields.

Legget (1904-1994) was educated in England as a civil engineer and is considered one of the "Fathers of Canadian Geotechnique."[1] The Canadian Geotechnical Society's most prestigious award is named after him. As the founding Director of the National Research Council's Division of Building Research, Legget was instrumental in initiating geotechnical research and organizing the geotechnical profession at the national level. In that position he also introduced safe building practices to Canada,[2] that included the development of the National Building Code of Canada and the National Fire Code of Canada, updated versions of which are still in use today. His avocation was history, especially the history of canals, railways, engineering and geology. Legget was an accomplished and prodigious writer and an engaging public speaker. He wrote numerous books and hundreds of articles and papers and lectured widely.

In 1981, the Canadian Geotechnical Society asked Jack Clark, then past president of the society, to chair a small committee to consider the best way to record the history of the geotechnical profession in Canada. Clark reported back that an effective way to tell the story would be by interviewing Legget, Robert Hardy of the University of Alberta,[3] and a few other selected individuals and preparing a book highlighting their recollections.

Hardy (left) and Legget. Photo taken in Edmonton in May 1983. Legget is wearing a blazer with the coat of arms of his *alma mater*, the University of Liverpool. (photo source University of Alberta Archives)

The Society agreed and in early 1982, Clark and David Townsend, another member of this small committee, contacted Legget and asked him if he would be willing to participate in this project. He agreed but indicated that he would rather write his contribution as opposed to being interviewed. Between mid-January and mid-March 1983, Legget, then 78 years old, wrote and submitted a 104-page manually typed and hand-edited manuscript titled *Geotechnique in Canada, a Personal Memoir*. In May 1983, he submitted an eight-page supplement to his original manuscript along with five pages of corrections and clarifications.



GEOTECHNIQUE in CANADA

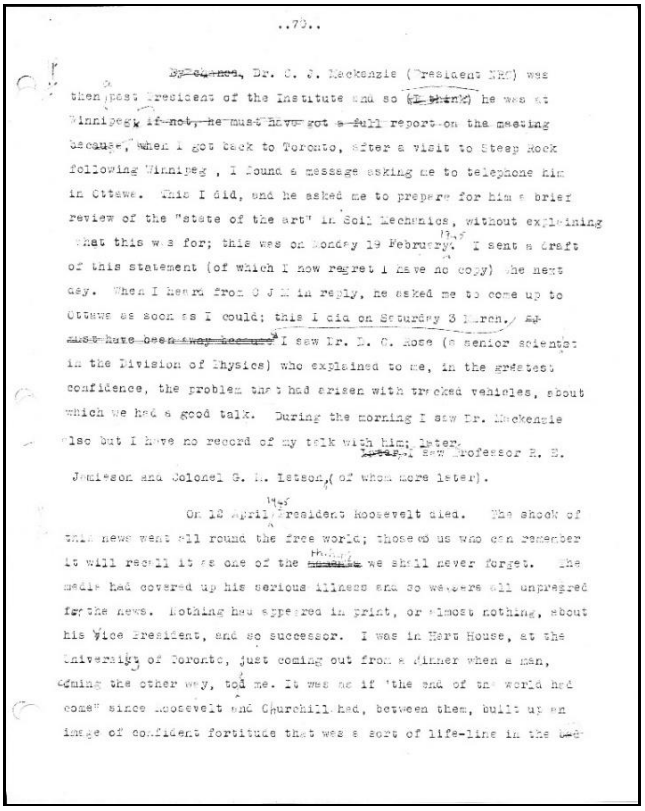
A PERSONAL MEMOIR

by

Robert F. Legget

531 Echo Drive,
Ottawa K1S 1N7

15 March 1983



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By chance, Dr. C. J. Mackenzie (President NRC) was then past President of the Institute and so (I think) he was at Winnipeg, if not, he must have got a full report on the meeting because, when I got back to Toronto, after a visit to Steep Rock following Winnipeg, I found a message asking me to telephone him in Ottawa. This I did, and he asked me to prepare for him a brief review of the "state of the art" in Soil Mechanics, without explaining what this was for; this was on Monday 14 February. I sent a draft of this statement (of which I now regret I have no copy) the next day. When I heard from C J M in reply, he asked me to come up to Ottawa as soon as I could; this I did on Saturday 5 March. As must have been two because I saw Dr. D. C. Rose (a senior scientist in the Division of Physics) who explained to me, in the greatest confidence, the problem that had arisen with wrecked vehicles, about which we had a good talk. During the morning I saw Dr. Mackenzie also but I have no record of my talk with him; later I saw Professor R. H. Jamieson and Colonel G. H. Letson, (of whom more later).

On 12 April 1945 President Roosevelt died. The shock of this news went all round the free world; those of us who can remember it will recall it as one of the moments we shall never forget. The media had covered up his serious illness and so we were all unprepared for the news. Nothing had appeared in print, or almost nothing, about his Vice President, and so successor. I was in Hart House, at the University of Toronto, just coming out from a dinner when a man, coming the other way, told me. It was as if the end of the world had come. Since Roosevelt and Churchill had, between them, built up an image of confident fortitude that was a sort of life-line in the bad

Title page and example page from Legget's 1983 memoir

As one of five members of the editorial committee of what became the "Canadian Geotechnical Heritage Book Project,"[4] I was provided a rather poor quality photocopy of Legget's memoir.

For various reasons, by 1986, the well-intentioned heritage committee and the Canadian Geotechnical Heritage Book Project languished.[5] Legget's memoir was never published and in the intervening years it has been all but forgotten.

In 2015, while President of the Canadian Geotechnical Society, I had occasion to refer to Legget's memoir and thought it valuable enough to have my poor quality photocopied version scanned and put on the Society's website (www.cgs.ca).

In 2018, I found myself referring to this memoir again and decided to convert the photocopied version to a "Word" document, incorporate Legget's hand-edits and then put this much easier-to-read version on the CGS website.

Once I started, I realized that I could make Legget's story even more interesting by adding annotations and photographs to his text. Then in 2019, a short supplement and some further corrections and clarifications to the memoir surfaced. Because the memoir generally covers the period between the early 1920s and the late 1960s, it seemed like a logical extension to add some additional biographical information on his life and legacy, and a selected bibliography.

This book is the result. It focuses on Legget's geotechnical career and his influence on the profession but introduces the many other sides of his life and career and provides some insight into the man.

I have tried to keep my edits of Legget's memoir to a minimum to allow his words and voice to come through. But where I noted errors or room for clarification, I have changed some of his original words. These changes, except for spelling and grammatical errors, are noted in italics in square parentheses. In his memoir, Legget is inconsistent in his punctuation and capitalization. His spelling is often more British than Canadian. I have purposely not made changes to these aspects except where the meaning could be misconstrued. Similarly, I have not changed Legget's use of Imperial units although, ironically, he was involved in Canada converting to the metric system.

This has turned out to be two books in one: 1) Legget's memoir (very close to a career autobiography) with my edits, annotations and added photos; and 2) my biographical additions. From the Table of Contents, the reader can see that I have inter-woven, somewhat chronologically, chapters of his memoir with my biographical sections. The reader can simply read his chapters (unshaded in the Table of Contents) or can read both his and my chapters (shaded in the Table of Contents) for a more complete story of his life. Legget's text and my text and annotations are presented in different fonts to minimize any confusion as to who wrote what.

Legget's footnotes are indicated by superscript capital letters in his text and are located at the bottom of the page where they are referenced. My annotations are indicated by superscript numbers, in both his and my chapters, and are located at the end of the chapter where they are referenced.

I have also prepared a separate document that contains just my annotations, *Annotations to accompany The Many Sides of Robert Legget*. Some readers may find it useful when reading the main text to have the compiled annotations available in a separate document.

I have included references to my contributions. My general sources of information are discussed and other references are listed in Chapter 24. As explained in that chapter, the acronym "LAC" refers to Library and Archives Canada.

Doug VanDine, Victoria, BC
August 2020

Annotations Chapter 1: INTRODUCTION

[1] "Geotechnique," the noun and "geotechnical," the adjective, describe an applied science that combines the principles and techniques of geology and hydrogeology with those of soil and rock mechanics, for construction on or under the ground's surface, for the extraction of the Earth's resources and for the prevention, management and mitigation of natural and environmental hazards.

[2] According to City of Ottawa Archives, "Canadians have to thank Robert Legget for wheelchair ramps, smoke detectors and hard hats for construction sites."

[3] Robert (Bob) Hardy (1905-1985) is considered the other "Father of Canadian Geotechnique." Hardy was a graduate of the University of Manitoba (bachelor's 1929) and McGill University (master's 1930). He started teaching in the Civil Engineering Department at the University of Alberta as a lecturer in 1930. After studying soil mechanics at the post-graduate level at Harvard under Arthur Casagrande in 1939 and 1940, he returned to the University of Alberta, established a soils laboratory and helped develop undergraduate and graduate soil mechanics programs in the department. The graduate program, which started in 1945, is considered the first full-time graduate program in soil mechanics in Canada. He became head of the Civil Engineering Department in 1946 and the following year he added the position of Dean of Engineering. Hardy retired from the university in 1959 to devote most of his time to his consulting practice, Hardy Associates (now a part of the Wood Group), but continued at the university as a part-time professor. In 1971, Hardy was the recipient of the 2nd Robert F. Legget Award. For more on Hardy see Harris 1997.

Whereas Legget and Hardy are considered the "Fathers of Canadian Geotechnique," Ibrahim Morrison should be considered the "Grandfather of Canadian Geotechnique." Morrison (1889-1958) joined the Department of Civil Engineering at the University of Alberta in 1912 and began teaching "Foundations" as a separate undergraduate course in the 1920s. In 1937, he renamed that course "Soil Mechanics and Foundations," the first such course in Canada. For more on Ibrahim Morrison see Harold Morrison 1997.

[4] Besides Jack Clark, Dave Townsend and myself, other members of the editorial committee were Bill Eden and Geoff Meyerhof. These gentlemen will be introduced later.

[5] For a more complete story of the CGS "Canadian Geotechnical Heritage Book Project," see VanDine and Heinz 2020.

Chapter 2: THE LEGGET FAMILY

Robert Ferguson Legget was born on September 29, 1904 in the Walton area of Liverpool, England, a short distance from the city centre. At the time, Liverpool had a population of almost 700,000. It was the largest city in the northwest of England and had been in existence for almost 700 years. From the beginning, Legget was visibly surrounded by history, a subject he embraced all his life.

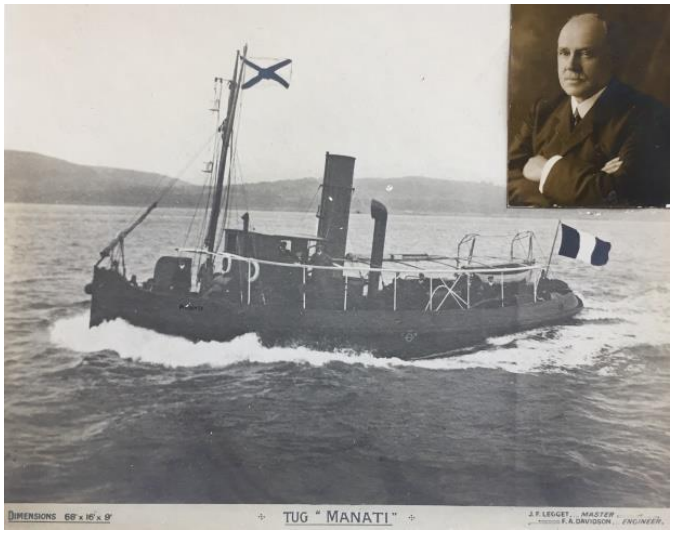
Liverpool waterfront and the Royal Liver Building (in background) in 1915.
The Royal Liver Building was completed in 1911. (photo source Baffledspirit Blogspot website)

Legget's ancestors had emigrated from Scotland and he was very proud of his Scottish heritage. The first known Leggets were skinners, tanners, fellmongers (dealers in sheep hides) and wool merchants in Edinburgh. Legget's great-great-grandfather, Robert Sommerville Legget, was born in Edinburgh in the mid-1790s and in the 1820s or 1830s he established the firm Robert Legget & Sons. For several generations that family business was the dominant tannery in Scotland.

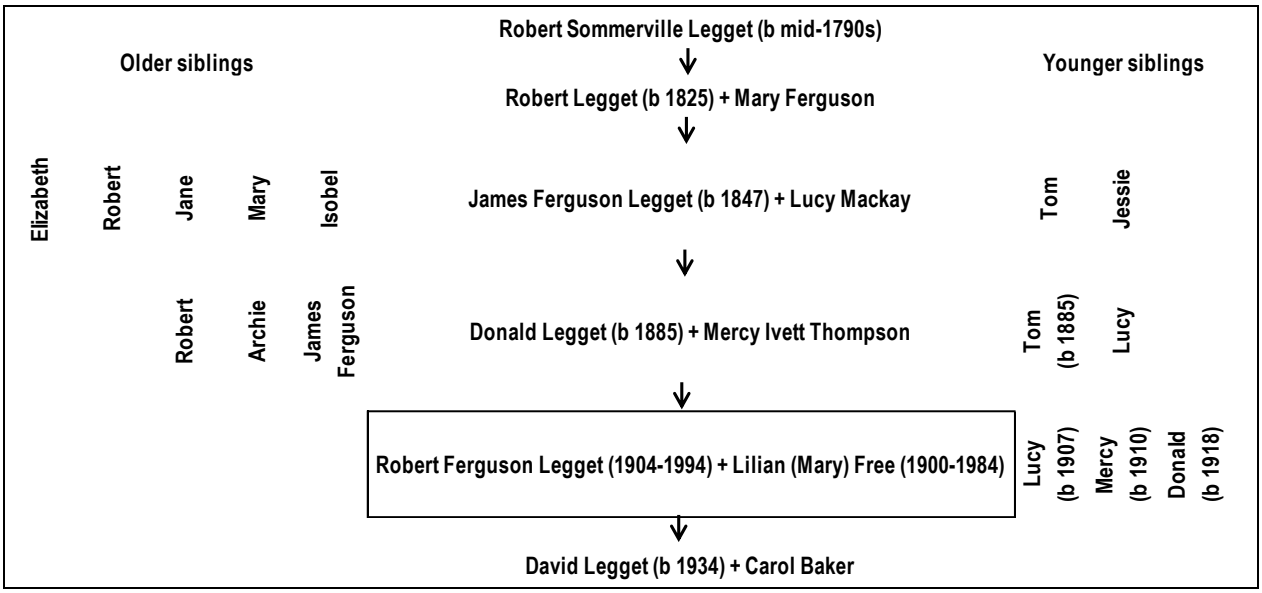
Legget's great grandfather, also called Robert, was born in Edinburgh in 1825 and became one of the "Sons" in the business. He married Mary Ferguson. Robert and Mary had eight children, all born in Edinburgh, the sixth of whom was Legget's paternal grandfather, James Ferguson Legget, born in 1847. In 1869, James married Legget's grandmother, Lucy MacKay, from Inveraray, in southwestern Scotland. They moved to Liverpool where James worked as a "Master Mariner" (Sea Captain).

Legget's maternal grandfather, Robert Thompson, was a tailor and draper in Birkenshire, England. Not much else is known of this side of the family.

James and Lucy Legget had five sons and a daughter, all born in Liverpool; twins Donald and Tom were born in 1885. Donald married another Liverpudlian, Mercy Ivett Thompson, in 1903 and Robert Ferguson Legget was born a year later. Both the names Robert and Ferguson have been in the Legget family for generations. Robert was followed by sisters Lucy in 1907 and Mercy in 1910, and brother Donald 1918, all born in Liverpool.



This photograph of Legget's grandfather, James Ferguson Legget (inset) and one of his charges, Tug "Manati." hung between Legget's bachelor's and master's degrees in his study at 531 Echo Drive (see Frontispiece). (LAC Special Collection, abbreviated elsewhere as LAC Spec Coll)



Simplified Legget Family Tree (adapted from LAC 1-5 plus other sources[1])

Legget's father worked as a clerk for a dry soap manufacturer, likely "Hudson's," which was purchased by Lever Brothers in 1908. He worked his way up to departmental manager. Sometime after Legget left home, his family moved to Port Sunlight, on the other side of the Mersey River from Liverpool.[2]

The only ancestor who appears to have had anything to do with engineering was Legget's uncle, James Ferguson Legget, who started his career as an engineering draughtsman and worked his way up to become an "Engineering Manager" with a construction company.

Annotations Chapter 2: THE LEGGET FAMILY

[1] This chapter was compiled from a family tree (LAC 1-5), the Edinburgh City Archives website, several online England and Wales census and registries and some information from Legget's distant relative Val Whinney.

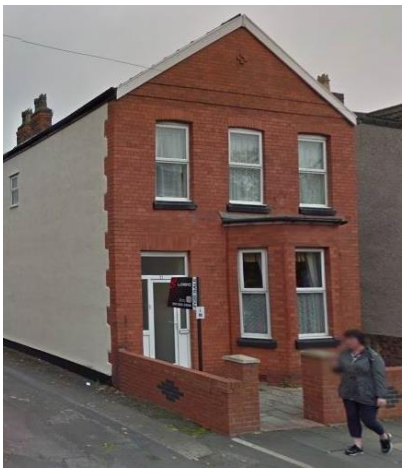
[2] Port Sunlight was named after the famous Lever Brothers product "Sunlight Soap" (Wikipedia).

Chapter 3: EARLY YEARS (1904-1922)

The first few years of Robert Legget's life were spent in a 300-year-old house with the delightful name Cherry Tree Cottage in Heswell, England, approximately 15 km southwest of Liverpool.[1]

Cherry Tree Cottage, Heswell, England (photo source Google Street View 2009)

By 1911, the family had moved to 21 Sandringham Road in the Waterloo area of Liverpool, where Legget attended first the Crosby North Council School and then the Christ Church Boys' School. His Grade 1 report card indicates that he ranked second out of 55 students in his class and "takes great interest and answers intelligently". In Grade 5, Legget improved his ranking to first.



Left: postcard of Sandringham Road in the Waterloo area of Liverpool, taken in the early part of the 20th century. 21 Sandringham is in the distance just before the bend in the road. (photo source Trevor Hildrey)
Right: 21 Sandringham Road (photo source Google Street View 2015).

Between 1915 and 1922, Legget attended Merchant Taylors' Boys' School—Crosby, an independent school for day students founded in 1620. He was an exceptional student and won numerous awards and scholarships. In 1921, among other honours, Legget won a scholarship

entitling him to free tuition for his final year at the school. In that final year, he was appointed a "promonitor", an assistant monitor of the younger students.

Main building of Merchant Taylors' School. This building, constructed in 1878, replaced the original main building constructed in 1620. The photo was taken in the late 1960s. (photo source Merchant Taylors' School)

In addition to his academic pursuits, Legget played rugby, was a member of the Musical Society Committee, the Literary Society and the Swimming Club, and was secretary of the Debating Society. Within the Debating Society, he was described in the school magazine as "speaking clearly, logically and dispassionately. At his best when grieved over the want of logic of his opponent."[2]

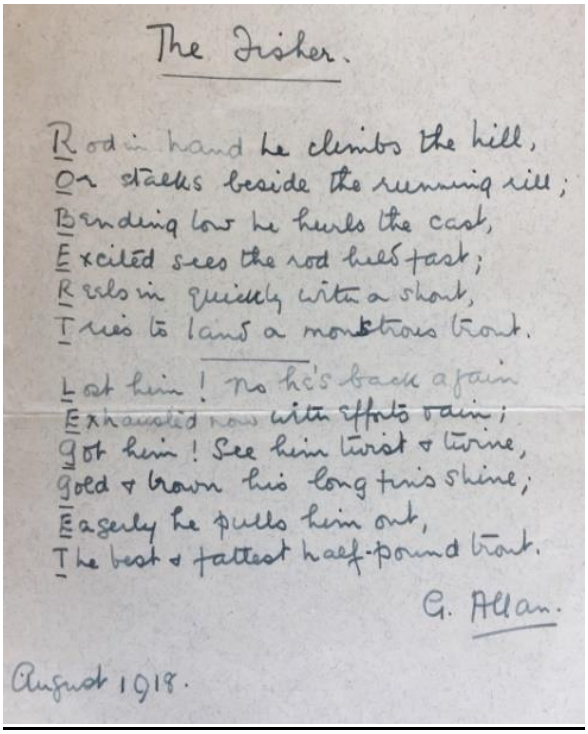
Legget and his friends at Merchant Taylors' School also enjoyed "train spotting"; a hobby of watching for trains and keeping a log of their distinctive characteristics. For Christmas in 1918, his parents gave him a "Kodak Brownie camera, which cost all of fifteen schillings,"[3] and he started his life-long hobby of photography, especially of trains. In the October 1919 issue of *The Railway Magazine,*[4] the 15-year-old Legget had his first photo of a train published and was likely thrilled to see his photo and his name in print for the first time. He continued to take photos of trains most of his life.

Photograph by Legget, published in the October 1919 issue of *The Railway Magazine* (LAC 7-2)

As a child and throughout his life, Legget regularly attended the Church of England (Anglican Church). Son David Legget describes his father as a “quiet Anglican who sang in the church choir as a youth.”

Legget and his family holidayed almost every year, even during the First World War, to destinations such as the Isle of Anglesey in northern Wales and to the Isle of Man in the Irish Sea. After the war, as Legget and his siblings got older, the family trips extended further to London and to Edinburgh.

Legget was a Boy Scout and was also known, to at least one friend, as a “fisher”. The friend, G. Allan, wrote a cleverly fashioned poem for Legget titled “The Fisher.”[5]


The Fisher.

Rod in hand he climbs the hill,
Or stalks beside the running rill;
Bending low he hurls the cast,
Excited sees the rod held fast;
Reels in quickly with a shout,
Tries to land a monstrous trout.

Lost him! No he's back again
Exhausted now with efforts vain;
Got him! See him twist & twine,
Gold & brown his long fins shine;
Eagerly he pulls him out,
The best & fattest half-pound trout.

G. Allan.

August 1918.

The Fisher

Rod in hand he climbs the hill,
Or stalks beside the running rill;
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The best & fattest half pound trout.

August 1918 G. Allan

Annotations Chapter 3: EARLY YEARS (1904-1922)

[1] David Legget, personal communication

[2] Most of this information is from the Merchant Taylors' School Archives. As an adult, Legget kept in touch with Merchant Taylors' School and was a member of its "Old Boys Association in Canada" (known as the "Crossbeans") for many years (LAC 1-25).

[3] LAC 3-9

[4] *The Railway Magazine,* a UK monthly magazine for railway enthusiasts, was first published in 1897 (Wikipedia).

[5] LAC 3-9

[Chapter 4: SPECIAL NOTE AND APOLOGIA]

SPECIAL NOTE

... to the reader:

This record has been prepared on the basis of entries in my work diary (I have never kept a diary in the usual sense), early records of the Associate Committee,[1] and privileged access for one or two matters to the wartime diaries of Dr. *[C.J.]* Mackenzie,[2] but chiefly upon my own memory, reactivated for this special task! It is as fallible as any other memory and so I apologise in advance for any unwitting inaccuracy, while asking all who note any inaccuracy (no matter how detailed) if they would be good enough to let me know of it, so that the final record may be as good as possible.

1 March 1983 R.F.L.[3]
531 Echo Drive,
Ottawa, KIS 1N7

GEOTECHNIQUE IN CANADA
A PERSONAL MEMOIR

by

Robert F. Legget

15 March 1983

APOLOGIA

Appreciation must first be recorded to those responsible for conceiving and developing the idea of preparing a record of the development of Geotechnique in Canada. Having been involved, to a degree, in this interesting chapter in the history of civil engineering in Canada, I should have thought long ago of getting at least some of my recollections down on paper. This I have never done, counting myself always too busy looking ahead. I make this admission with regret and no little embarrassment in view of my own interest in, and writing about, the history of engineering in this country. So it is that I welcomed cordially the invitation of Jack Clark and David Townsend[4] to get my memories in this field on paper. Once I had seen the need for this (with their help!) I gave much thought to the matter. The more I thought, the more I was driven to the conclusion that the only possible way for me to make a useful contribution would necessitate writing a very personal memoir. Never having done anything like this before, it has not been easy! My friends know that I am "old-fashioned" enough to write my technical papers always in the third person, so that to have to start writing "I" does not come naturally. But it must be done and so, with embarrassment, here goes....

Annotations Chapter 4: SPECIAL NOTE AND APOLOGIA

[1] The Associate Committee on Soil and Snow Mechanics of the National Research Council. It was renamed the Associate Committee on Geotechnical Research in 1965. These committees led to the formation of the Canadian Geotechnical Society in 1972.

[2] Chalmers Jack Mackenzie (1888-1984) was a civil engineering graduate of "Dalhousie College and University" (as it was known then), in Halifax, NS, in 1909. In 1912, he was hired by the University of Saskatchewan to develop its engineering program. In 1939, Mackenzie moved to Ottawa and served as Acting President of the National Research Council (NRC), filling in for President of the NRC, General Andrew McNaughton, who had rejoined the military. Mackenzie served in that capacity for most of the Second World War, becoming President of the NRC in 1944 and serving until 1952. Later he became the first President of Atomic Energy of Canada Limited, the first President of Atomic Energy Control Board and the second Chancellor of Carleton University (1954-1968) (Wikipedia).

[3] Robert Ferguson Legget often referred to himself as R.F.L. or RFL.

[4] As introduced in Chapter 1, Jack Clark and David Townsend were members of the Canadian Geotechnical Society's early-1980s heritage book committee.

Jack Clark (1932-2010) was a prominent geotechnical engineer in Canada. He was a CGS President (1979-1980) and the 14th Robert Legget Award winner (1983). See the CGS website (Lives Lived) for more on Clark.

David Townsend (1926-1999) taught in the Department of Civil Engineering, Queen's University in Kingston, ON, from the mid-1950s to the late 1960s and was very influential in the formation of the CGS in the early 1970s. He later worked with Golder Associates in Mississauga, ON, and with RM Hardy & Associates and Gulf Oil in Calgary, AB. In 1991, he retired to Victoria, BC.

[Chapter 5:] EARLY TRAINING (1922-1929)

Reflecting upon my good fortune in participating in the formal start of soil mechanics as a discipline in civil engineering, a very small activity when it did start, caused me to realise how my early training had "conditioned me," for being receptive to any such move in connection with soils. I must, therefore, go back to my professional beginnings if what follows is to make sense.

Through an entirely unexpected scholarship, I was enabled to enter the University of Liverpool as an undergraduate in 1922[1] (instead of becoming a bank clerk![2]). Liverpool was then, and still is, one of the leading "Red-brick Universities" of England with fine standards.[3] Because of my schooling *[at Merchant Taylors' School—Crosby]*, I was permitted to enter the second year at the end of which I elected to take civil engineering, without really knowing too much about it.[4]

Civil was a small department, distinguished by a fine lecturer in structures and by the fact that, in order to take an honours degree, all civil students had to take a special minor-honours course in geology. This included short but good introductions to petrology, paleontology and geological mapping, all with laboratory instruction as well as lectures, all supplementary to the main course of lectures on geology for civil engineers by the head of the *[Geology]* Department, Professor P.G.H. Boswell,[5] the finest and most inspiring teacher I have ever had.

I still have my lecture notes from that course[6] and they show what an admirable introduction to the subject "P.G.H." gave to us, including due reference to soils. His own First World War research had been in connection with sand; he retained his interest in soils throughout his life. He was the Professor of Geology at Liverpool from 1917 to 1930 when he left to take up the Chair of Geology at Imperial College, London, an indication of his standing in the profession. But he was plagued by ill-health and had to retire in 1938. Cared for by his wife, he spent most of the remainder of his life in nursing homes but even here his active mind was always at work.

Towards the end (he died in 1960), he wrote a series of essays or short notes on various aspects of soil and these were published (posthumously) as *Muddy Sediments*, a small book of 140 pages, published by W. Heffer & Sons Ltd. of Cambridge.[7] It is not a very good book, containing some strange and even incorrect ideas. Boswell himself had no illusions about this, saying in his Preface that it was merely "Simple tales for simple souls," but I go into this detail since, to the best of my knowledge, it is the only book about soils of recent years written by a hard-rock geologist.

The most remarkable thing about geology at Liverpool for civil engineers was that Professor Boswell was able to insist that all civil engineers taking the honours course must take a full week of geological field work in the Easter vacation. In my case, this was spent at the old town of Ledbury[8] near the English-Welsh border. We stayed in an old inn, were out in the field by eight every morning, working until five, returning for dinner and then spending the evening

plotting our results for the day. At the time, I remember so well, we "kicked like steers" (as students would) about this "slave-driving" but, looking back, I am quite sure that the week in the field, with Boswell and his two lecturers, was the most profitable week of my university training.

We were trained in the art of observation, by three expert field geologists and this, coupled with earlier training as a Boy Scout (and especially in Kim's Game[9]), has been of inestimable benefit to me ever since. I only wish that there was some way of ensuring that every undergraduate in civil engineering could have similar training, in the lecture-hall and in the field. I have always appreciated this training from soon after graduation but only since I was forced to look back, in thinking about Geotechnique in Canada, have I realised fully that the seeds planted by Boswell in those impressionable years must have had some influence in what happened later.

Having always been interested in railways (I am still a "buff"[10]), I had hoped to get a job with one of the main British railways after graduation.[11] This, however, was at a time of the great amalgamations; the railways had too many civil engineers; so I had to look at other fields. Water power engineering had also attracted me. I found that the largest power project to be built in the United Kingdom (located in the north of Scotland[12]) was being designed, and so I wrote to the consulting engineers *[involved]* in London. Invited to go for an interview, I made the "terrific" journey to London (all of 200 miles, but I was the first member of my family to wander so far afield[13]) and was interviewed by Mr. W.T. Halcrow, the head of an old firm of consultants, then known as C.S. Meik and Buchanan.[14] (C.S. Meik had been one of the resident engineers on the building of the Forth Bridge[15]).

I got a letter offering me a pupilage with the firm; that is, I would be an assistant engineer for two years, would pay £300[16] for this privilege, and get it back in monthly payments...and up to that time this was the only way in which one entered the profession of civil engineering in the United Kingdom, even with a degree. I had to turn this offer down since I had to earn my own living, but within a couple of weeks I got another letter *[from the same firm],* this time offering me a job as assistant engineer at the princely salary of £150 per year (on which I managed to live in London). Later, I found that I was the first such assistant ever to be paid in that office, pupils were still being recruited for some years after that!

It was an old-fashioned office[17] in which I learned much from a wise old chief draftsman, but my main good fortune was in acting as Mr. Halcrow's "technical office boy;" doing calculations and trial designs to satisfy his thinking. One job stands out; the fact that I can remember it so clearly shows that it must have influenced my own thinking. In order to locate the Lochaber power house, at the end of large steel penstocks coming from the Lochaber tunnel (see below), a large programme of test boring was carried out over an area of about half a mile square. Working under Mr. Halcrow's direction, I prepared and roughly costed sixteen separate schemes and saw these being compared, in a fine exercise of engineering economics, until a final selection was made. I have never forgotten the value of that intensive site investigation.[18]

Mr. Halcrow was a quiet, kindly man; he later became Sir William and the same firm is

today *[known]* as Sir William Halcrow & Partners, the largest firm of consultants in the United Kingdom.[19] I suppose that I must have "made noises" about getting up to the job *[site in Scotland]*, construction now in full swing, since he allowed me to have a six-month period with the Resident Engineer; and later a further longer period as activity on the job peaked.[20]

The tunnel noted is 79,000 ft long and 15 ft 6 inches in diameter, going right under Ben Nevis, the highest mountain in the British Isles.[21] Geology, therefore, dominated the job; all the resident staff were knowledgeable and some of this must have rubbed off on me too, especially my contacts with one of the two assistants, Resident Engineer Ben Peach. He was the son of the great Dr. *[Benjamin]* Peach[22] who first unraveled the geological structure of the Scottish Highlands. Himself a geologist of note, Ben Peach taught me a lot; his son, with the same name is now a Professor of Geology at Brock University *[in Canada]*![23]

The geology along the tunnel route had been predicted by Dr. Bailey, later head of the British Geological Survey (I think);[24] he and other geologists came up to see the tunnel work in progress. It went well, with no unusual difficulties, rock being as expected. Sundays, spent in the absolute quiet of the tunnel, doing essential survey work, provided an experience never to be forgotten. All in all, I was a fortunate youth to see such a job at first hand, every aspect of it confirming what P.G.H. Boswell had taught in a general way.[25]

But I could see the end of the job coming, with the long tunnel holed through and the steel penstocks in place. I had caught the "construction bug" and could see that there would rarely, if ever, be as big a job as Lochaber again in the United Kingdom. So for reasons that I can not fully recall, and after finding out that New Zealand was, even then, so socialised a country that opportunities in construction were limited, I decided to come to Canada. Mr. Halcrow understood; he had gained oversees experience.[26] One of his former colleagues, A.D. Swan, who had gone to Canada and been very successful as a consultant, encouraged me when he came in to see the staff in the old office on Victoria Street, Westminster *[London],* and so I sailed from Liverpool in March 1929.[27]

Annotations Chapter 5: EARLY TRAINING (1922-1929)

[1] Legget registered in the Faculty of Engineering on September 30, 1922, a day after his 18th birthday. In August of that year, he was awarded the "Lancashire County Scholarship…for Proficiency in Secondary School Subjects," with a value of £60, for each of his three undergraduate years. These amounts covered his entire undergraduate tuition fees which were £50 per year (University of Liverpool Archives). £50 in 1922 would be approximately CDN$5,000 in 2020.

[2] In 1979, Legget recalled thinking he wouldn't be going to university: "I had obtained a job as a bank clerk; I had even bought a bowler hat" (LAC 9-6).

[3] The University of Liverpool was founded as a college in 1881 and became a university in 1903. The Faculty of Engineering was established in 1902 and Civil Engineering became a department in 1908. Currently the university has approximately 33,000 students (University of Liverpool website). In a 1976 letter, Legget describes the Civil Engineering Department in the early 1920s as a "then-small department occupying an old house on Bedford Street." (University of Liverpool Archives)

Oblique air photo of the older central portion of the University of Liverpool (photo source Google Maps 2018)

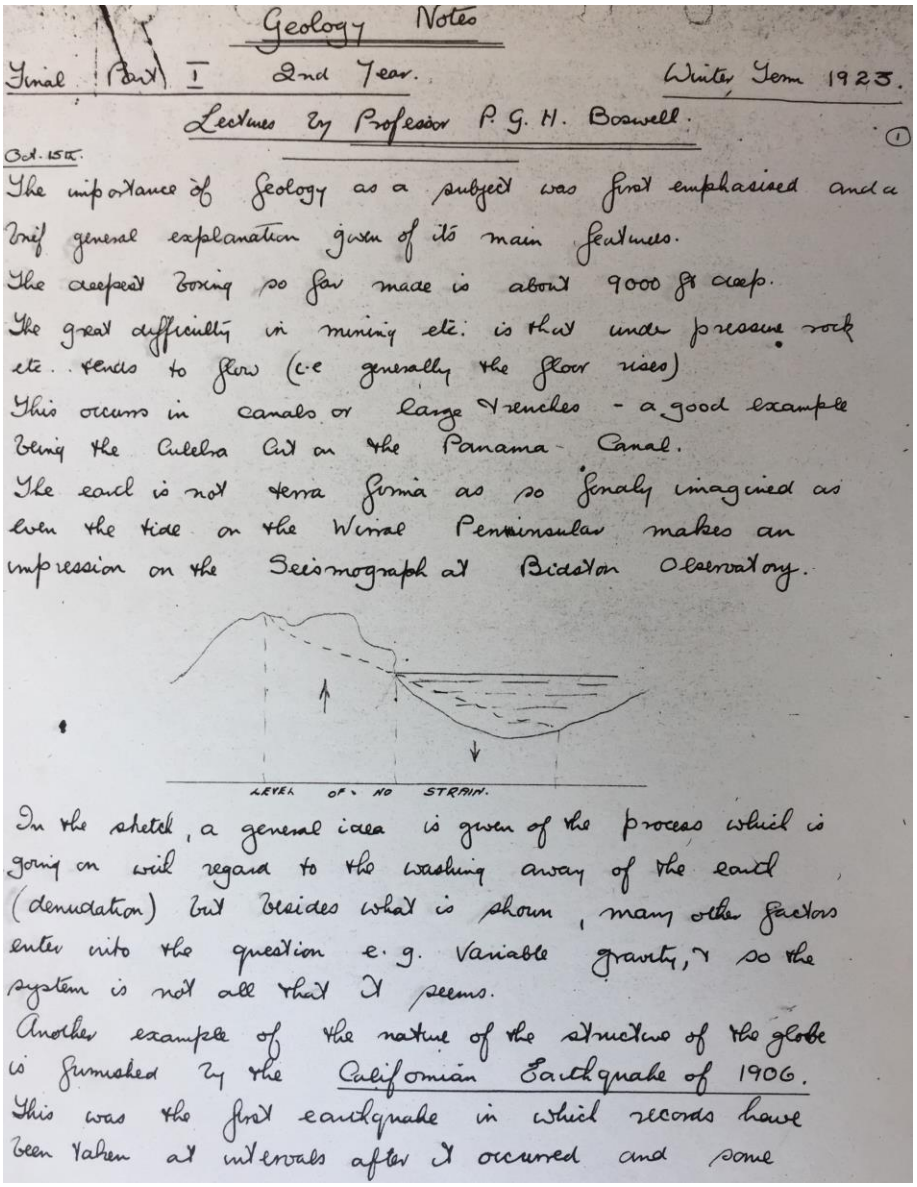
[4] In another 1976 letter, Legget reminisced that Professor Abell, the Dean of Engineering at the University of Liverpool in the early 1920s, "guided me into civil engineering, in a kindly and wise way, and so I have long been in his debt" (University of Liverpool Archives).

[5] Percy George Hamnall Boswell (1886-1960) became a Fellow of the Geological Society of London (1907), an Officer of the Order of the British Empire (1918) and a Fellow of the Royal Society (1931). He was President of the Geological Society of London during 1941 and 1942 (Geological Society of London website).

A portrait of P.G.H. Boswell from a 1961 Royal Society memoir (LAC 3-22)

An indication of what Legget thought of Boswell is shown by the fact that Legget asked Boswell to write the foreword to Legget's first textbook, *Geology and Engineering*, published in 1939.

[6] A portion of Legget's detailed handwritten geology notes from 1923 (LAC 9-19).



Geology Notes

Final Part I 2nd Year. Winter Term 1923.

Lectures by Professor P. G. H. Boswell.

Oct. 15th. (1)

The importance of Geology as a subject was first emphasised and a brief general explanation given of its main features.

The deepest boring so far made is about 9000 ft deep.

The great difficulty in mining etc. is that under pressure rock etc. tends to flow (i.e generally the floor rises)

This occurs in canals or large trenches - a good example being the Culebra Cut on the Panama Canal.

The earth is not terra firma as so finely imagined as even the tide on the Wirral Peninsular makes an impression on the Seismograph at Bidston Observatory.

In the sketch, a general idea is given of the process which is going on with regard to the washing away of the earth (denudation) but besides what is shown, many other factors enter into the question e.g. Variable gravity, so the system is not all that it seems.

Another example of the nature of the structure of the globe is furnished by the Californian Earthquake of 1906.

This was the first earthquake in which records have been taken at intervals after it occurred and some

[7] *Muddy Sediments: Some Geotechnical Studies for Geologists, Engineers and Soil Scientists* by P.G.H. Boswell, 1961, published by W. Heffer & Sons. Founded in Cambridge in 1876, that publisher became part of the Blackwell Group in 1999; however, there still is a Heffers Bookshop in Cambridge (*The Guardian* website).

[8] The Town of Ledbury, between Worchester to the north and Gloucester to the south, is approximately 200 km south of Liverpool.

[9] Kim's Game is named after the hero in Rudyard Kipling's 1901 novel *Kim*. The hero plays the game during his training as a spy. The game helps develop observational and memory skills (Wikipedia).

[10] As mentioned in Chapter 3, Legget was an avid train spotter and had his first photograph of a train published in *The Railway Magazine* in 1919. In 1929, he wrote his first of many articles for the same

magazine. In 1989, he wrote to the editor and offered to write an article on being a contributor for 70 years. His offer wasn't accepted (LAC 16-13). Over the years, Legget also wrote for other railway magazines including *The Railway Gazette, Canadian Rail* and *The Canadian National Railways Magazine.*

In 1949, Legget was the second author, after Charles P. Disney, of an illustrated book titled *Modern Railway Structures*, published by McGraw-Hill (see Chapter 16). In 1973, Legget published *Railways of Canada*. Four years later, he published a 96-page coffee-table book entitled *Canadian Railways in Pictures.*

[11] It is not clear from the text, but Legget is probably referring to his 1925 graduation from the University of Liverpool with a BEng. As he describes in the following paragraphs, he worked in London with C.S. Meik and Buchanan, consulting engineers. He worked with that firm from the fall of 1925 to the spring of 1926, then returned to the University of Liverpool, where he completed his MEng in the early summer of 1927 before returning to London.

[12] The Lochaber Hydroelectric Power Project

[13] It is interesting that Legget says he "was the first member of my family to wander so far afield," because he recorded his travels to "Wilford & London" in 1921 when he was 17 years old (LAC 2-1).

[14] William Halcrow (1883-1958) was a notable English civil engineer. He was knighted in 1944, in part because of his civil engineering contributions during the Second World War. He was elected President of the Institution of Civil Engineers in 1946.

The engineering consulting firm C.S. Meik and Buchanan was established in 1868 under the name Thomas Meik, the father of Charles Scott Meik (Halcrow 1993).

[15] The Forth Bridge is a 2.4 km long railway bridge, completed in 1890, that crosses the Firth of Forth, approximately 25 km west of Edinburgh. It is a UNESCO World Heritage Site (Wikipedia).

Firth of Forth Bridge under construction in the late 1880s (photo source BBC News website)

[16] £300 in 1925 would be approximately CDN$30,000 in 2020.

[17] C.S. Meik and Buchanan's office was at 16 Victoria Street in the Westminster area of London. It was destroyed during the Second World War.

[18] Before working on the Lochaber Hydroelectric Power Project, Legget worked on a number of smaller projects "as personal assistant to Mr. W.T. Halcrow…engaged on calculations and the preparation of contract documents for hydro electric schemes in Scotland, Greece, Italy, Finland, etc., and upon Dock Harbour and general civil engineering work" (Queen's University and NRC Archives).

[19] The firm C.S. Meik and Buchanan was renamed C.S. Meik and Halcrow sometime after Legget left in 1929, although *125 Years of Halcrow*, published by the Halcrow Group in 1993, indicates the name change was in 1923. In a 1993 unpublished note, Legget disputed the 1923 date. In the same note, Legget commented that when he worked with the firm, William Halcrow was known simply as "Bill Halcrow" (LAC 19-12).

An undated photo of William Halcrow (LAC 19-12)

The name of the company was changed in 1941 to W.T. Halcrow & Partners, in 1944 to Sir William Halcrow & Partners and in 1998 to the Halcrow Group. In 2011, the company was acquired by CH2M Hill and in 2017 CH2M was acquired by Jacobs Engineering Group (Wikipedia).

[20] According to Legget's files, he spent a portion of the summer of 1927 and from October 1928 to March 1929 on the Lochaber project site (LAC Spec Coll).

[21] The Lochaber Hydroelectric Power Project, constructed between 1924 and 1929, is located in the western Scottish Highlands. It was constructed to provide electricity to the Lochaber Aluminum Smelter in the adjacent town of Fort William. The Lochaber tunnel is 24 km long and until 1970 it was the longest water tunnel in the world (Wikipedia).

The Lochaber tunnel delivers water from Loch Treig (on the right), beneath Ben Nevis (pinned in the lower left), to the penstocks and the power generating station, located approximately 2.5 km northeast of Fort William. The width of the image shown is approximately 30 km. North is to the top. (modified from Google Earth 2019)

The Lochaber tunnel under construction (LAC Spec Coll)

[22] Benjamin Neeve Peach (1842-1926) became a Fellow of the Royal Society (1892), a Fellow of the Royal Society of Edinburgh (1881) and a Fellow of the Royal Geographical Society (Wikipedia).

[23] When Legget wrote his memoir in 1983, it was Peter Peach, not Ben Peach, who was a Professor of Geology at Brock University, St. Catharines, ON. Peter Peach had previously taught at the University of Toronto. There is now a Peter Peach Memorial Award in the Department of Earth Sciences at Brock University (Brock University website).

[24] Sir Edward Battersby Bailey (1881-1965) became a Fellow of the Royal Society (1930) and a Fellow of the Royal Society of Edinburgh. He was Director of the British Geological Survey from 1937 to 1945 (Wikipedia).

[25] Legget summarized his Lochaber experience as (Queen's University and NRC Archives):

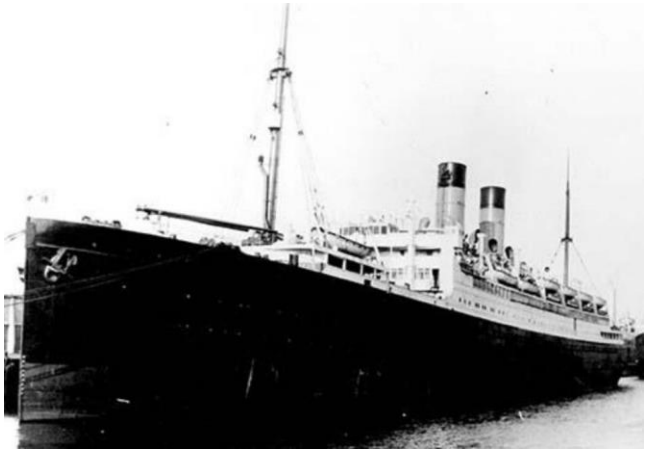
> (120,000 H.P. [approximately 90 Megawatts] under 800 feet head), including the complete design of the Surge Chamber, and high pressure, all welded steel pipe line. Two periods were spent on the construction of this project. For one period as an assistant to the Chief Resident Engineer in charge of the construction of the Surge Chamber and Portal Tunnels. The scheme includes what was then the largest tunnel in the world (15 miles long, 15 1/2 feet diameter) on which much experience was gained.

[26] In 1910, Halcrow worked in Singapore on the King George V Dock (Wikipedia).

[27] As a 24-year-old, Legget left from the Prince's Dock in Liverpool, on board the *SS Albertic* on March 30, 1929 (Canadian Museum of Immigration, Pier 21 website).

Prince's Dock, Liverpool, in 1920 (photo source Vintag website)

SS Albertic was built and launched in Germany in 1920; however, she was given to the British government as part of war reparations. She initially sailed as the *SS Ohio* for the Royal Mail Steam Packet Company. In 1927, she was sold to the White Star Line and renamed *SS Albertic*. She served on the trans-Atlantic service between Britain and Canada from April 1927 until August 1930, then anchored in the River Clyde, Scotland, because of the Depression. In 1934, she was broken up for scrap in Japan (Wikipedia).



SS Albertic (photo source Canadian Museum of Immigration at Pier 21)

Chapter 6: UNIVERSITY AND LONDON YEARS (1922-1929)

Between 1922 and 1925, while attending the University of Liverpool, Robert Legget lived with his family at 13 Sandringham Road,[1] a semi-detached house, only a few houses from where the family had previously lived at 21 Sandringham Road.

13 Sandringham Road (now known as 15A) Sandringham Road (photo source Google Street View 2015)

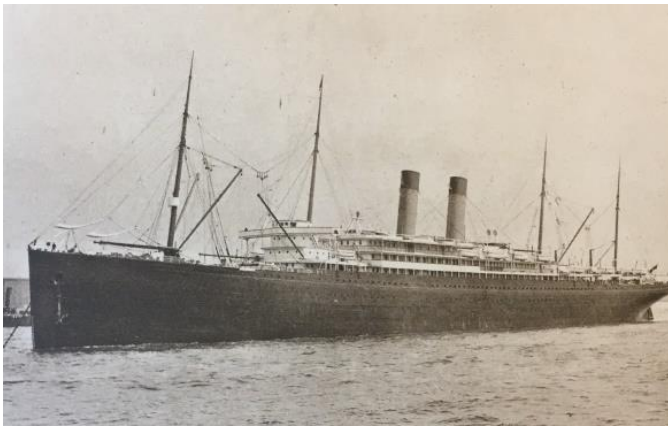
While an undergraduate, Legget developed an interest in writing and wrote several short notes on a variety of topics. For example, “A New Use for Old Tyres” was published in a 1923 issue of *Everyday Science,* a popular British science periodical of the day. “An Easily Made Automatic Print-Washer” was published in a 1924 issue of *The Amateur Photographer & Photography,* a weekly British photography magazine. A note on his “Civil Engineering Camp” experiences was published in a 1924 issue of the *Sphinx*, the University of Liverpool’s student newspaper.[2]

To gain practical experience, during the summer of 1923, Legget worked in Liverpool with the Mersey Docks and Harbour Board.

The following summer he had two summer jobs. For one month he worked in the City of Liverpool’s Engineering Office “gaining a knowledge of road construction and maintenance, particularly as to the manufacture and laying of tarred macadam, the construction of outfall sewers the analysis and testing of Cement, Pitch and Creosote Oil.”[3] For another month in 1924, Legget worked in the engine room aboard the *RMS Celtic*[4] as a “supernumerary engineer” (an extra engineer). He sailed from Liverpool to New York, with landfalls at Cobh (Queenstown) on the south coast of County Cork in Ireland and at Boston, MA.

This trip, his first Atlantic crossing and visit to New York City made quite an impression on the 23-year-old Legget. He kept a log of his voyage and on his return he typed and bound a 47-

page journal including a full description of the workings and specifications of the ship and engine room, a daily log and many photos, including one of himself in his work overalls.



Above: postcard of the *RMS Celtic.* Right: Legget working aboard the *RMS Celtic.* This is the earliest known photo of Legget. Both photos from Legget's journal. (LAC 1-30)

As an undergraduate, Legget became involved in both the Liverpool Engineering Society and the Guild of Undergraduate Students. He was secretary for both groups.[5]

He graduated with a "Hons BEng Class 1" in 1925. At the time, "Class 1" indicated an average grade of 70% or greater. Upon graduation, Legget asked his geology professor to write a letter of reference on his behalf. Boswell wrote somewhat prophetically:[6]

> His prowess has been remarkably good, indeed he is one of the best Engineering students who has passed through my hands. Not only is he widely read, but he has shown much aptitude for practical work, in particular, geological surveying and map-making.
>
> Mr. Legget gets on well with his fellow-students and has the capacity for managing men. He took a considerable part in the organizing and social activities of his Guild of Undergraduates.
>
> I feel sure that he has a brilliant future before him in the engineering world. He possesses a likeable personality and a sterling character.

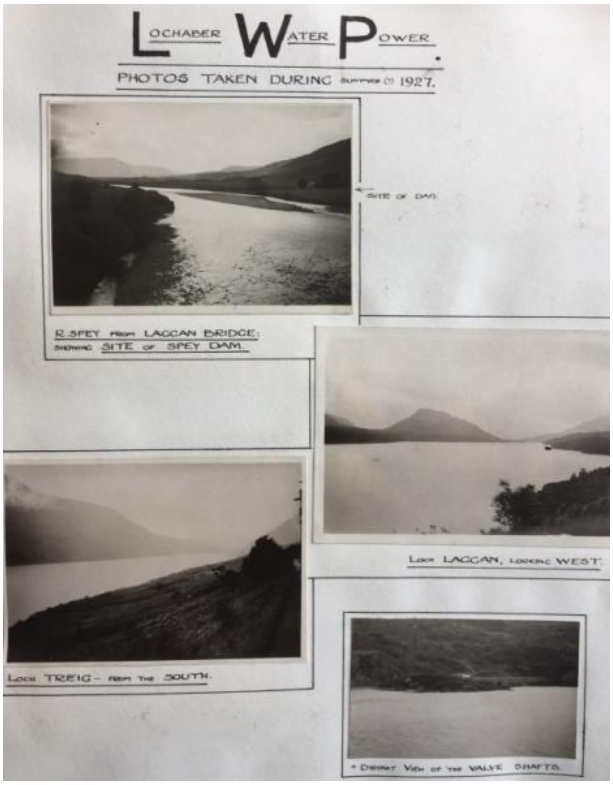
Upon graduation, Legget moved to London for two periods between 1925 and 1929. In the interim, from fall 1926 to spring 1927, he returned to the University of Liverpool and obtained his MEng degree in civil engineering. Not much is known about his time as a graduate student other than that his main focus of studies was "water power."

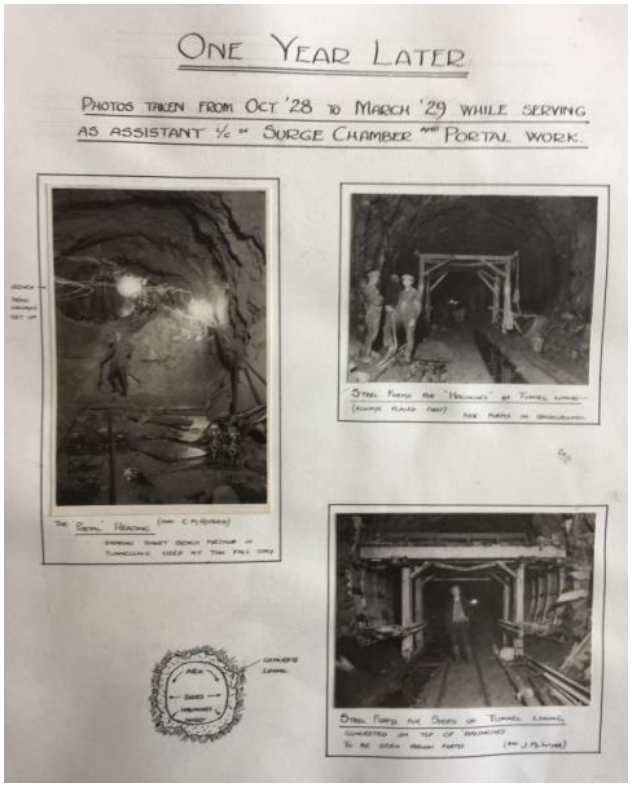
During both periods in London, as he describes in his memoir, Legget worked for C.S. Meik and Buchanan. During the latter period, he worked on site at the Lochaber Hydroelectric Power project, in Scotland.

In 1984, of his time working with C.S. Meik and Buchanan, he wrote:[7]

> My work at No. 16 Victoria Street seemed, at the time, to be an interesting job in a rather grubby office with a small group of friendly and devoted people. … it did not take long for me to realise that I been fortunate beyond words at No. 16 and up at Lochaber and that the four years had been very much more than just a job. I trust that some of the comments in this Note will have made very clear how deeply I was and still am indebted to the Firm for some of the finest training and experience that any young civil engineer could wish to have at the start of his professional work.

As with his *RMS Celtic* experience in 1924, Legget kept journals of his field work experiences at the Lochaber Hydroelectric Power Project.





Several pages from Legget's Lochaber journals, 1927-1929 (LAC Spec Coll)

While in London, Legget continued his habit of writing and started to give presentations. He published his first article in *The Railway Magazine,* contributed a short article to *The Kodak Magazine*[8] and co-authored a paper in the Water Power Section of the UK journal *Water and Water Engineering.* Legget authored papers and gave presentations on "Photography and Engineering," "The Limitations of Concrete as a Material in Construction" and "Some Considerations of our Power Resources" to local engineering groups. The last presentation was based on his final graduate paper, for which he won several awards from the Institution of Civil Engineers.

Legget also assisted a senior engineer with C.S. Meik and Buchanan in preparing a paper titled “The Surge-Chamber in Hydro-Electric Installations, Methods of Calculation” published by the Institution of Civil Engineers. He was quite proud of the role he played in its preparation.[9]

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Mr. Robert F. Leggett, of "Rothsay," Waterloo Park, who received the James Forrest medal, the James Prescott Joule medal, and a Miller prize for student papers read before the London Association of the Institute of Civil Engineers. The paper for which the medals and prize were awarded by the Council of the Institute of C.E. was entitled "Some Considerations of our Power Resources," and was read in February before the London Association.

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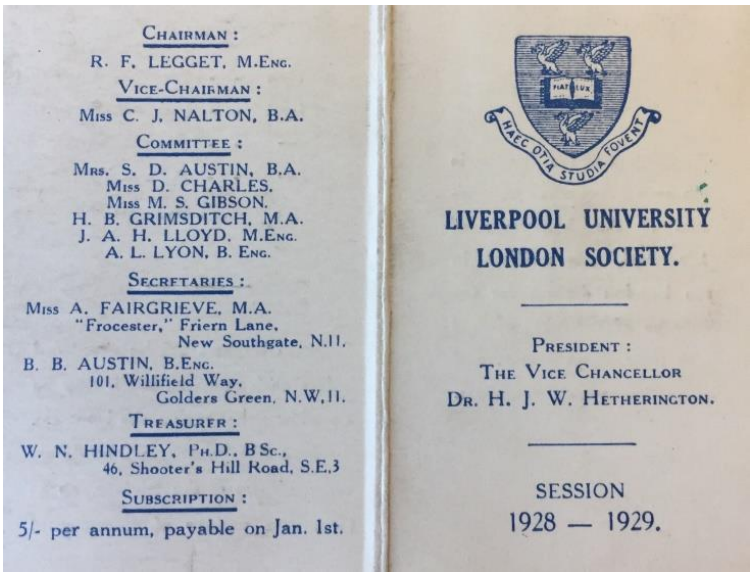
Published in the *Waterloo Crosby (Liverpool) Herald*, October 14, 1927. (LAC 1-28)

In London in 1925, Legget also continued his practice of getting involved. He became a member of the London Student Section of the Institution of Civil Engineers, the Liverpool University London Society, the London branch of the Liverpool Engineering Society and the (UK) Geologists’ Association.[10] During 1928 and 1929, he was Chairman of the Liverpool University London Society.



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SESSION
1928 — 1929.

Legget was Chairman of the Liverpool University London Society during the 1928-1929 session (LAC 1-28)

Between 1925 and 1929, Legget lived in three different boarding houses: 2 Spencer Hill, 91 Woodside (both in the Wimbledon area of London and both approximately 10 km from his work) and 123 St. George's Square (in Westminster, much closer to his work).



Left to right: 2 Spencer Hill, 91 Woodside and 123 St. George's Square
(photo sources Google Street View 2018 and 2019)

Legget's boarding house at 123 St. George Street was owned and operated by "Toc:H," an international Christian movement that Legget joined while living in London.[11] He described his experience living there as "enjoying the fellowship and accepting the somewhat spartan living for the convenience of being so centrally located."[12]

While in London, Legget kept in touch with his friends in Liverpool and made new friends, a habit he would keep for the rest of his life. One Christmas he organized, from London, an "Olde Time Xmas Revel" in Liverpool for his Liverpudlian friends.


1925 XMAS EVE: 1926
A SNOWFLAKE.
THE PLEASURE OF YOUR COMPANY IS REQUESTED BY A NUMBER OF PEOPLE AT AN
OLDE TIME XMAS REVEL
TO BE HELD AT YE 'ANGEL' HOSTELRIE IN DALE STREET – LIVERPOOL (NEXT TO YE CAFÉ OF STATE)
AT 6.15 OF YE CLOCK
ON FRIDAY DECEMBER 24TH 1926
PLEASE BRING:-
① 2/6 ② THY SONG BOOK
③ THE BEST STORY YOU HAVE HEARD DURING THE YEAR ④ CONVIVIALITY (& H.L)
R.S.V.P. before MONDAY DEC. 20TH.
to R.F. LEGGET, 2, SPENCER HILL, WIMBLEDON S.W.19.

Legget's handwritten Christmas Eve invitation to the "Olde Time Xmas Revel" in Liverpool (LAC Spec Coll)

Legget also got to know Miss Lilian Free in London. Miss Free was the secretary of Sir George Buchanan,[13] the senior partner of the firm C.S. Meik and Buchanan. In Legget's words she was the "maid of all work" in the firm. Miss Free was the only woman working in the office.[14] As will be discussed in Chapter 7, Legget must have spent some of his time in London "dating" Miss Free.

Annotations Chapter 6: UNIVERSITY AND LONDON YEARS (1922-1929)

[1] Sometime after the 1920s, 13 Sandringham Road was re-numbered 15A, likely to avoid the superstition around the number 13, a superstition known as triskaidekaphobia.

[2] LAC 4-6, 4-7 and 4-8

[3] LAC 1-8

[4] The *RMS Celtic* was an ocean liner in the White Star Line fleet, the same fleet as the *RMS Titanic*. (The RMS designation means Royal Mail Ship with a contract to carry mail.) She was built and launched in Belfast in 1901 and could carry approximately 2,800 passengers. During the First World War she stuck a mine, 17 people on board were killed but the ship survived. In 1928, she became stranded on rocks near Cobh, Ireland and although freed, was written off due to structural damage. She was finally dismantled for scrap in 1933 (Wikipedia).

[5] University of Liverpool Archives

[6] LAC 1-8

[7] LAC 9-9

[8] *The Kodak Magazine* was published by the Eastman Kodak Company in Rochester, NY, and was first published in 1920 (Wikipedia).

[9] Queen's University Archives

[10] The Geologists' Association was founded in 1858. It is an association for amateur geologists, not to be confused with the professional geologists' Geological Society of London, established in 1807 (Wikipedia).

[11] Toc:H was founded in Belgium during the First World War by a British Army chaplain, Neville Talbot, as a "soldiers' rest and recreation centre." The unusual name is the abbreviation for Talbot House. At that time "Toc" was the British Army's military word for the letter "T" (the word "Tango" is now used). The organization expanded to London in 1920. It is still active in several countries today (Wikipedia).

[12] LAC 20-23

[13] Sir George Buchanan (1865-1940) was knighted for his work in the First World War. He had a very interesting, although somewhat checkered, engineering career (Wikipedia).

[14] LAC 9-9

[Chapter 7:] CANADA PRE-CONFERENCE[1] (1929-1936)

Arriving in Montreal (by way of Halifax[2] and CNR[3]) in the early spring of 1929, six months before the depression broke over North America, was an exhilarating experience. There was a shortage of engineers and so one had a choice of jobs; I had five offers, all pressing. I elected to join the Power Corporation *[of Canada]* since they promised me construction experience. (In those days, the newly established Power Corporation was designing, building and financing new power plants for the power companies which it had bought up).[4]

Dominion Day[5] 1929 therefore found me up in the Cobalt district of northern Ontario, as Resident Engineer and assistant to the *[Construction]* Superintendent of the Upper Notch *[Hydroelectric Power]* plant, to be built on the Montreal River[6] for the Northern Canada Power Co. In slightly less than 18 months, from the first clearing on the site, we had the plant operating and turned over to the power company. The plant was then the largest completely automatic power plant in Canada, but generated only 13,000 HP.[7] This was a wonderful experience for me, in many ways; I came "out" of our camp in the bush only three times in the eighteen months.[8] In this context, however, there are only two things to be related since the dam and power house were all founded on bedrock and built of concrete.

In our excavation for the power house, on the east bank of the Montreal River, I had my first encounter with glacial till, as tough as any I have ever seen since. I wondered how we were going to move this stuff on our tight schedule but I need not have worried. Our general foreman, a man who could neither read nor write, was wise indeed in the ways of construction. After he had examined the till and saw what it was like, he ordered a powerful pump and some fire hose; as soon as he personally directed the first high pressure water jet at this rock-like material, I watched it disintegrate before my eyes and flow down the wooden trough below, the grades being suitable for gravity flow. In just a day or two, the excavation was complete, and I had learned another lesson about "soil."[9]

Near its entry into Lake Timiskaming, the Montreal River then flowed through a very narrow gorge. This provided an "obvious" site for another water power development and so, in our second summer, we were asked to see what we could find out about foundation conditions at the gorge, called the Lower Notch.[10]

We had some of Canada's best "river-men" on the job; it did not take them long to get timber cribs firmly anchored in the turbulent water at the head of the gorge, from which diamond drilling[11] was then to be carried out (a photo of the drill set-up being one that I have used several times to illustrate test drilling).[12] I went down by canoe regularly to inspect the work and to "keep an eye" on it; in this way I learned much that was useful about rigging,[13] river work, and diamond drilling. Our drilling started with wash boring[14] and continued in the same way, in mid-river, since we never

did reach "bottom" *[bedrock]* (although later work showed that we were only a few feet from the bottom of the gorge in our wash boring through sand).

It is an interesting commentary upon Canadian development to find that the Lower Notch plant has now been built (by Ontario Hydro),[15] *[with the]* crest level being such that it has flooded out completely our Upper Notch plant, the machinery from which was removed before all our good concrete was submerged never, probably, to see the light of day again.[16]

One "side-effect" of the Upper Notch job is of relevance. I had been introduced at 16 Victoria Street*[the office of C.S Meik and Buchanan]*, as a part of my training, to the then current periodical literature of civil engineering, the two fine UK journals (now sadly changed) and *Engineering News-Record.*[17] In those days *EN-R* was a really professional journal, advertising front and back only, contents including full accounts of engineering projects and research. So I read and noted the famous 1925 articles by *[Dr. Karl]* Terzaghi,[18] his first North American publications. Somehow the editors of *EN-R* heard about the Upper Notch job, presumably since we were placing almost all the concrete under winter conditions. They wrote and asked for an article; the Chief asked me to do it; I did and the article was duly published.[19] The associated correspondence included a friendly exchange with the Senior Editor, Van T. Boughton, who had worked in his early days on the other Montreal River of northern Ontario.[20]

[The editors of EN-R] remembered this since, in mid-1933, they wrote and asked if I would like to be their (spare-time) engineering correspondent in Montreal. One did not refuse anything in those days and so I gladly accepted. My first short news note appeared on 14 December 1933; today, I am still privileged to be (now) a special correspondent to the Editor.[21] In this way I learned how to read a newspaper so as to be able to pick out any item of engineering significance. More than this, however, it led to close friendships with Van Boughton and Waldo Bowman, the two men who "ran the paper" in those years. And Van told me the story of the 1925 *[Terzaghi]* articles—how they came in to the Editor, F.E. Schmidt, who found them so badly written that he put them in his waste-paper basket; Van rescued them from there, rewrote them after seeing their value, and so helped to launch Terzaghi on his North American career.

Living in the bush prevented me from realising the full extent or meaning of the depression, despite the news that we did get. But it did not take long after "coming out" at the end of 1930 (and getting married, in a quick visit to the United Kingdom)[22] to realise, when living in Montreal, how very serious economic affairs were becoming. This is no place for any details of what those days were like, so let me merely record that, after seeing that much of the work in the Power Company office was "made work"[23] it was not too much of a surprise when, on a day in February 1932 (at the very depth of the depression), the Corporation discharged about thirty of us engineers, all married men, some with children, all having been promised "permanent" jobs. And at that time, one third of all the engineers of Canada were out of work.

I was very fortunate, yet again, for within a few weeks I was offered and accepted a job with the Sun Life Insurance Company to operate their new building, the details of which are here

irrelevant.[24] But when unemployed one has time to think and so, with my wife, we did a lot of thinking and talking about the future, optimistic about the future in a way that now seems almost irrational! I had seen so clearly the fundamental importance of geology in civil engineering, and especially the geology of soils, that I was surprised at the almost complete neglect of the matter in the literature of civil engineering, with which I kept in touch.

I wanted to talk with someone about this. It may have been through Dean *[Ernest]* Brown (Engineering, McGill *[University]*, a fellow graduate of *[the University of]* Liverpool), but somehow I was advised to ask Professor J.J. O'Neill, then Professor of Geology at McGill (later to be Dean of Science, and then Vice Principal), if he would see me. He said he'd be glad to and so I went to his office at McGill on 10 March 1932[25] for a talk that would prove to be another turning point in my life. Happily, I was able to keep in touch with Dr. O'Neill until just before he died;[26] his friendship was a rewarding experience; I think that he knew how I valued it.

I was then only 28, still naive in many ways, and I "walked in off the street" so to speak. And yet this great man gave me far more than an hour of his time and talked with me as if I were one of his prized students. I found that he had similar ideas to P.G.H. Boswell, in realising the place that geology should occupy in civil engineering. He knew, and regretted, the way in which it had been almost forgotten and thought that "something should be done about it." He was sure that this was a field of activity for the future, and finally told me that if you really wanted to learn about something, the best way was to try to write about it. This latter advice being something that I, in turn, have often tried to pass on. It finished up with him suggesting that I should write a paper on Geology and Engineering and try to get it accepted by the Engineering Institute of Canada,[27] in those days at the peak of its professional service with a very active Montreal Branch.

So I got busy, keeping in touch with Dr. O'Neill who eventually read the paper that I prepared. When I had his approval, I submitted it to the EIC. They asked me to present it to a regular meeting of the Montreal Branch (which I did on 18 January 1934) and then asked for it for the *Engineering Journal*[28] where it appeared in due course in print.[A 29] Active discussion at the meeting led to new and rewarding friendships. A copy of the paper went, naturally, to P.G.H. Boswell who also approved, so much so that, to my amazement, he asked me to join with him as a co-author of a book on the subject that the well-known British publishers, Edward Arnold Ltd., had asked him to write. He was good enough to say that the paper was really a synopsis of the book he had in mind; would I please go ahead and prepare a detailed outline of what I thought the book should contain.

Responding to this challenge occupied all my evenings for many weeks but eventually I had a complete outline of what I thought such a book should contain. I had separate sheets for each chapter, and headings for each section of every chapter.

My new work, to be related shortly, took me to England in the summer of 1935. Professor

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[A] Legget R.F. (1934), "Geology and Civil Engineering; their relationship with reference to Canada," *Engineering Journal*, Vol 17, pp 422-442.

Boswell invited me to luncheon at the Athaneum,[30] a great thrill in itself for a youngster such as me; after lunch we adjourned to a small room and there, without saying a word, he went right through the outline I had prepared. At the end, he looked up, made some appreciative comment to the effect that it was fine but added, "I want you to change one word." When I asked which word, he replied, "My name; take it out. This is your book...." Argument was of no avail; he was too busy etc., and the outline was the book (I found out, much later, how right he was in this). He said that he would write a foreword, which he did, but insisted upon my getting busy and writing it. I relate this detail as further evidence of the greatness of this man to whom I owe so much.

After my return to Canada, he agreed that it would be awkward for me to deal with a British publisher and fully agreed with my taking it to McGraw-Hill[31] in New York with what results will be related later. Here, however, I should note that the last chapter in the first (1939) edition of the book (*Geology and Engineering*) deals with "Soils and Soil Mechanics."[32] The chapter was written after the 1936 Conference, however, the concept of a chapter on soils was there in the outline of 1935.

Now I must revert to 1932. In the early Fall, I was advised of an opening with a new small company just embarking on the sale of British-made steel sheet piling in Canada. This was close enough to foundation engineering to be of interest, so I applied. I found, to my pleasure, that the little company was an offshoot of the British Steel Piling Company of England,[33] which I had come to know before coming to Canada. They were suppliers of Larssen steel piling which I already knew to be in a class by itself because of the patented Larssen interlock.[34]

The little Canadian company was essentially a sales office but the British company insisted that they must have an engineer, quite divorced from sales, to assist engineers with design work and to inspect and assist with every installation of Larssen piling in Canada, to ensure that all were well done. This was the job; I was fortunate to be appointed and then had the benefit of a good training period with one of the senior BSP engineers who was in Canada for this purpose. When he returned to England, I was on my own, apart from regular contact by mail; it was the beginning of four most interesting years.[35]

The world-wide Larssen companies had pioneered the use of steel sheet piling as a permanent unit in construction, especially for retaining walls. This fitted to the needs of Canada at the time, when much construction was government-sponsored and geared to local needs. Accordingly, I got to know all the district engineers of the Department of Public Works, Canada, in the eastern part of the country (as far west as Winnipeg), seeing what devoted public servants these men were, with wide areas of jurisdiction, small budgets but many difficult jobs.

Keeping timber crib wharf and breakwater structures in repair was a widespread problem. Steel sheet piling provided a perfect solution since, with good design, it could be driven all round an existing, deteriorating timber rock-filled crib without the necessity of removing the cribwork, always a difficult and costly job. All round the Atlantic Coast line of Canada may be seen today small structures reconstructed in this way. When conditions were suitable, new structures could

likewise be economically built with steel sheet piling; one of the best examples is the large Marginal Way coal dock at the east end of Toronto Harbour, an area of several acres, surrounded with Larssen piling, tied back to anchorages, the whole *[interior]* filled with sand dredged from the lake bottom.[36]

[[Editor's note: Legget suggested inserting his May 1983 "supplement" here, however, it is really a sidebar to the story and therefore it has been given a separate chapter, Chapter 19.]]

The design of such structures was a nice problem in statics! The piling, when in place, was a vertical beam, fixed at one end (in the ground) and supported on a point support near the other (by tie rods). An elegant graphical solution to the problem had been developed in Germany by a Dr. Blum (I think), based on or related to work by Dr. Lohmeyer. None of this had been published in English, the information I got about it coming from BSP Ltd. I always intended to "write it up" and think that I still have my notes for this but, as will shortly be seen, time for this always eluded me.[B] I mention it now since every case depended on the assumptions made about the soils involved, and upon the assumed distribution of soil pressure. It always surprised me that the great US steel companies, or *[at least]* one of them, did not latch on to the Larssen patent so as to open up a whole new market for their output.

Just before the war, when the name of Germany was in disrepute, *[one of the US steel companies]* tried to break the Larssen patent and one of my most interesting assignments ever, resulted in a day spent as an "expert witness" explaining to the Master of the US Court of Claims, in Washington DC, what the "interlocked section modulus" of steel sheet piling was, and why you could not use this with the interlocks on US sheet piling. It took a whole day, but the Master, an outstanding lawyer, eventually got a clear understanding and the case was as good as won. But the war started before the judgement was given, and another small chapter in North American civil engineering was closed.

Prior to this, an engineer named (I think) Benoyer had a series of articles in *Civil Engineering*[37]—written on behalf of either US Steel or Bethlehem Steel[38]—outlining design methods for steel sheet pile walls etc, lifted from German work to which either little or no acknowledgment was made. *[The articles]* had little effect on practice in North America, or rather in the USA, because you can not use the interlocked section modulus with US Piling and so the economy of this method of construction becomes questionable. Z-shaped steel piles were introduced to try and get around the problem, but they proved difficult to drive and so have not come into wide use. (There was also a small Canadian sequel; a record of that is for another day).

Readers of this note may think that I have forgotten my main thesis—the development of Geotechnique in Canada. Not so! I have quite deliberately allowed myself to go into this detail about the uses of steel sheet piling because, now looking back, I find myself convinced that it was

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B For an introduction, see Legget R.F. (1936), "Steel Piling; Some Notes on its Development and Use," *Engineering Journal*, Vol 19, pp 273-280 (given to Toronto Branch, EIC on 6 March 1936).

the development of steel sheet piling in Europe, and especially in Germany, that was one of the major factors in the final recognition of Soil Mechanics as discipline. The general explanation, which I have myself used, is that it was the attention given to landslides (on the Panama and Kiel Canals,[39] and the Swedish State Railways[40]) that sparked the concerted interest in soils. This, coupled with the great pioneer work of Terzaghi, led to the recognition of Soil Mechanics and the holding, in 1936, of the first international conference at which the (somewhat unfortunate) name of "Soil Mechanics"[41] received its formal recognition. But I am now as certain as I can be that it was the use of steel sheet piling as a permanent unit in civil engineering practice, due to the work in Germany which I have touched upon, consequent upon the development of the Larssen interlock, that was yet another influence in this development, although generally unrecognised.

Against this background, it was quite natural that I should have noticed in an issue of *Engineering News-Record* in the spring of 1936 a tiny item about a proposed conference on soils and "soil mechanics" to be held at Harvard University. I wrote to Arthur Casagrande,[42] got a kindly reply, and duly registered for the meeting with the support of the Piling Company. I did not realise that it would take over 3,000 words *[in this memoir]* to provide the background for my attendance at the Conference. I have not hesitated, however, to give the foregoing explanation since I would not wish it to be thought that it was by some touch of inspiration "out of the blue" that led me to participate in this significant gathering. It can now be seen that, thanks to unusual good fortune in my early years in civil engineering, I had been conditioned to appreciate the importance of soils so that I was ready for the call when it came.

Annotations Chapter 7: CANADA PRE-CONFERENCE (1929-1936)

[1] The International Conference on Soil Mechanics and Foundations Engineering. The name of the International Society for Soil Mechanics and Foundations Engineering was changed to the International Society for Soil Mechanics and Geotechnical Engineering in 1997. The ISSMGE held its 19th conference in South Korea in 2017.

[2] Legget, aboard the *SS Albertic* and after having landfalls in Glasgow and Belfast, arrived at Pier 21 in Halifax, NS, on April 7, 1929, along with 517 other passengers.

Pier 21 was opened in March 1928. Between 1928 and 1971, this Halifax immigration depot was the point of entry into Canada for approximately one million immigrants. It is now a National Historic Site and home of Canada's Museum of Immigration (Canadian Museum of Immigration, Pier 21 website).

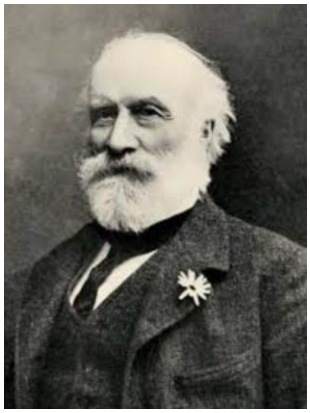
A passenger ship arriving at Pier 21 in Halifax in the late 1920s
(photo source CBC.ca-Seven Wonders of Canada website)

When Legget landed, he was surprised to be met by a member of Toc:H, the organization he had joined in London (see annotation in Chapter 6). Unbeknownst to Legget, that organization had telegraphed the Halifax Toc:H branch with information of Legget's arrival. The Halifax Toc:H member and Legget spent a few hours together in the city before Legget boarded an immigrant train for Montreal (LAC 20-23).

[3] The CNR or Canadian National Railways (the plural is correct) boarded immigrants at a special train station located in the Annex Building connected to Pier 21. In the 1920s, immigrant trains were relatively primitive compared to regular passenger trains. These lower class trains were heated by coal-burning stoves at each end of the car and offered only marginal dining facilities.

The 1,350 km rail line that connects Halifax and Montreal was constructed shortly after the Confederation of Canada in 1867, with Sandford Fleming as the Engineer in Chief. It was part of the Intercolonial Railway until it became part of the CNR in 1919.

Among other things, Sir Sandford Fleming, (1827-1915) went on to help build the Canadian Pacific Railway, promote standard times zones around the world and the use of the 24-hour clock, design Canada's first postage stamp and co-found the Alpine Club of Canada and the Rideau Curling Club, among other things. He was a founding member of the Royal Society of Canada and was Chancellor of Queen's University in Kingston for 35 years. He was knighted in 1897 (Wikipedia and Queen's University Archives websites).



Sir Sandford Fleming, date unknown (photo source Queen's University website)

With Legget's interest in trains and railways, and having seen nothing of Canada, he would have been fascinated by this leg of his trip. In later years he wrote a number of articles about both the Intercolonial Railway and Sir Sandford Fleming.

[4] The Power Corporation of Canada, founded in 1925, started buying existing hydroelectric power companies in Quebec, Ontario, Manitoba and BC and then started building other hydroelectric power plants. By 1929, the parent company and its affiliated companies were operating almost 40 power plants across Canada. The company also established a land development division to encourage new industries to locate near its power plants. In addition, the company opened retail stores to sell electrical goods. Both initiatives were obviously intended to promote power consumption.

In the 1960s, when provincial governments nationalized most hydroelectric companies, Power Corporation diversified into Canadian financial services, insurance, land and water transportation, pulp and paper, newspapers, real estate and even a radio station and a race track. Today, the Power Corporation is a diversified international management and holding company with interests in financial services, asset management, sustainable and renewable energy and other business sectors (Power Corporation website).

[5] The name "Dominion Day," the holiday to commemorate the Confederation of Canada on July 1, 1867, was changed to "Canada Day" in 1982, shortly before Legget wrote his memoir.

[6] There are two Montreal rivers in Ontario (see later annotation). The one to which Legget refers flows into Lake Timiskaming, a widening of the Ottawa River, along the Ontario-Quebec border. The Upper Notch project was located approximately 15 km upstream of the mouth of this Montreal River, approximately halfway between the early-1900s towns of Cobalt and Temagami.

[7] 13,000 horsepower (HP) is approximately 9.7 megawatts (MW).

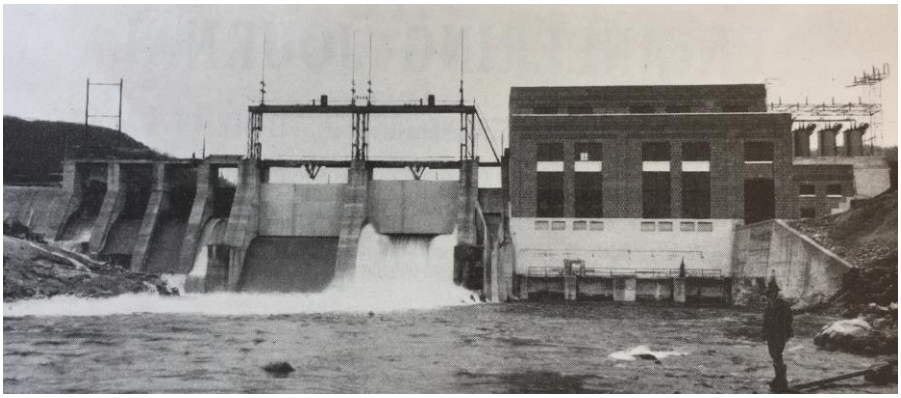


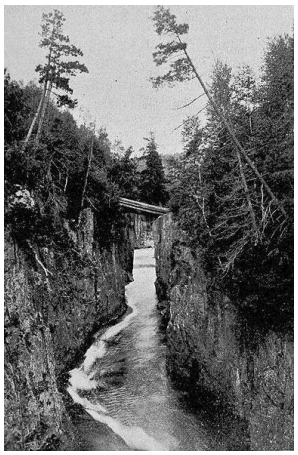
Photo of the completed Upper Notch Power Plant from Legget's 1931 paper in the *Engineering News-Record* (LAC 4-18)

[8] In 1936 and 1947, in statements of qualifications that Legget prepared for his employment at Queen's University and the National Research Council, respectively, he summarized his Upper Notch experience as (Queen's University and NRC Archives):

> Engineer with the Power Corporation of Canada Limited, Construction Division, and for 18 months (i.e. from the start to the finish) Resident Engineer and assistant to the Construction Superintendent, on the construction of the Upper Notch Water Power Plant, the largest automatic plant in Canada (13,000 [HP]) 75% of the concrete on the job being placed under winter conditions with temperatures as low as forty degrees below zero. The job included a 33-mile 110,000 volt transmission line. Work was described in Engineering News-Record for 29th October 1931, and in other publications.

[9] Legget's first experience with glacial till made an impression on him. In 1976, he was editor of the textbook, *Glacial till; an interdisciplinary study*, published by the Royal Society of Canada.

[10] The Lower Notch (or simply the Notch) was approximately 15 km down river from the Upper Notch.



"The Notch, Montreal River (Timiskaming District), 1906" (photo source *Missions in new Ontario*, 1906 by Rev. James Allen, published by Methodist Church, Toronto)

[11] Diamond drilling was invented in 1863 by Rodolphe Leschot, a French engineer.

[12] Legget took and used a number of similar photos. The photo below was published as Figure 11.10 in Chapter 11, Subsurface Investigations, in *Handbook of Geology in Civil Engineering*, by Legget and Paul Karrow, published in 1983 by McGraw-Hill. The caption reads, "Diamond drilling at the Lower Notch, Montreal River, many years before a dam was constructed at this site."

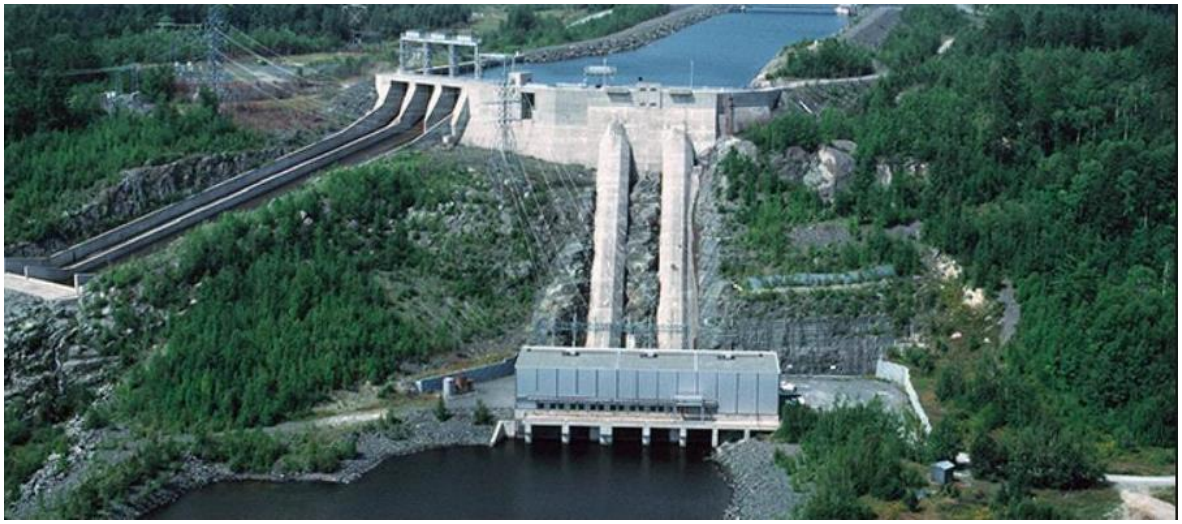
Photo of drill set up on Montreal River (photo by Legget)

[13] Rigging is a nautical term referring to a system of ropes, cables and/or chains to support the mast (standing rigging) and the sails (running rigging). In Legget's context, he is referring to the use of such a system to support the timber cribs and drilling equipment.

[14] Wash boring is a relatively primitive method of soil drilling that has been used for many hundreds of years.

[15] The Hydro-Electric Power Commission of Ontario was founded in 1906 and changed its name to Ontario Hydro in 1974. In 1999, the power generation side of Ontario Hydro became Ontario Power Generation and the transmission and distribution side became Hydro One Limited (Wikipedia).

[16] The Hydro-Electric Power Commission of Ontario took over operation of the private hydroelectric power plants on the Montreal River in 1944. It carried out subsequent investigations of the Lower Notch site in the early 1960s and constructed the Lower Notch Dam and Generating Station in the late 1960s and early 1970s. The plant was commissioned in 1971 (Ontario Power Generation website).



Lower Notch Dam and Generating Station (photo source Ontario Power Generation website)

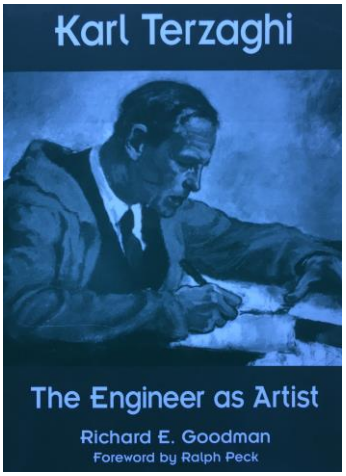
Currently the Lower Notch Generation Station has a capacity of 274 MW, compared to the Upper Notch plant that had a capacity of approximately 9.7 MW.

[17] It is not known to which two "fine UK journals" Legget was referring. In the 1930s, he published articles in three such journals: *Civil Engineering and Public Works Review*; *Concrete and Constructional Engineers* and *Water and Water Engineering*.

The *Engineering News-Record (EN-R)* traces its roots to two publications. The older magazine was first published as *The Engineer and Surveyor* in 1874. It was renamed several times to *The Engineer, Architect and Surveyor*, then *Engineering News and American Railway Journal* and eventually *Engineering News*. The second publication was first known as *The Plumber and Sanitary Engineer*. It was later renamed *The Sanitary Engineer*, then *Engineering and Building Record* and finally *Engineering Record*. In 1917, *Engineering News* and *Engineering Record* merged to become the magazine that is still published today (Wikipedia).

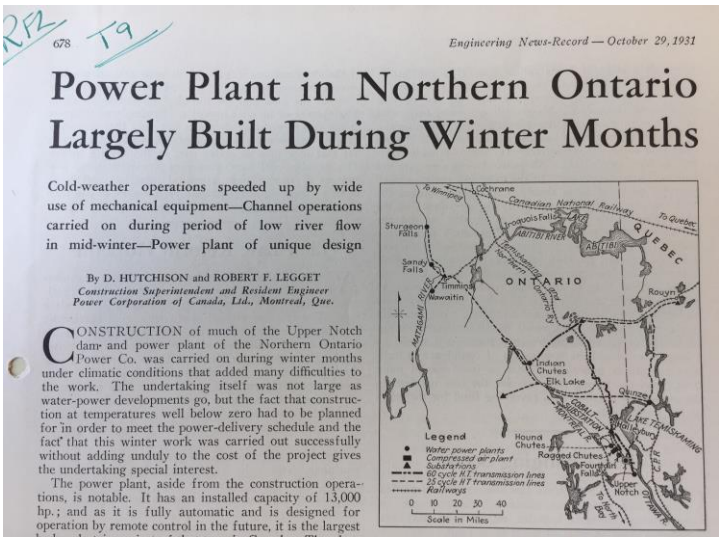
[18] Karl Terzaghi (1883-1963), born in what was then the Austrian Empire, is considered the "Father of Soil Mechanics." The 1925 articles by Terzaghi, to which Legget refers, are a series of eight articles titled "Principles of Soil Mechanics" that appeared in *EN-R*, Volume 95, pages 742-746, 796-800, 832-836, 874-878, 912-915, 987-990, 1026-1029 and 1064-1068. The following year, the articles were published in a 98-page book titled *Principles of Soil Mechanics: a summary of experimental studies of clay and sand*, published by McGraw-Hill.

For more information on Karl Terzaghi see Wikipedia and Goodman 1999.



Terzaghi portrayed on the cover of Goodman 1999

[19] The photo below is of the first page of Legget's five-page *EN-R* article, published on October 29, 1931 (LAC 4-18)



678 T9

Engineering News-Record — October 29, 1931

Power Plant in Northern Ontario Largely Built During Winter Months

Cold-weather operations speeded up by wide use of mechanical equipment—Channel operations carried on during period of low river flow in mid-winter—Power plant of unique design

By D. HUTCHISON and ROBERT F. LEGGET
Construction Superintendent and Resident Engineer Power Corporation of Canada, Ltd., Montreal, Que.

CONSTRUCTION of much of the Upper Notch dam and power plant of the Northern Ontario Power Co. was carried on during winter months under climatic conditions that added many difficulties to the work. The undertaking itself was not large as water-power developments go, but the fact that construction at temperatures well below zero had to be planned for in order to meet the power-delivery schedule and the fact that this winter work was carried out successfully without adding unduly to the cost of the project gives the undertaking special interest.

The power plant, aside from the construction operations, is notable. It has an installed capacity of 13,000 hp.; and as it is fully automatic and is designed for operation by remote control in the future, it is the largest

Article "By D. Hutchinson and Robert F. Legget, Construction Superintendent and Resident Engineer, Power Corporation of Canada Ltd., Montreal, Que." Legget wrote his initials and "T9" in the upper left corner of this article. He had started to code file his papers; T9 refers to what he considered his 9th published technical paper. (LAC 4 18)

[20] The "other" Montreal River in northern Ontario is in the Algoma and Sudbury districts and flows southwesterly into Lake Superior.

[21] Legget was a "(spare-time) engineering correspondent" and later a special correspondent to the Editor of *EN-R* for exactly 50 years. Over that period he contributed hundreds of relatively short news items about Canadian engineering to the magazine, all without a byline. He cut out most, if not all, of his published contributions and pasted them into two scrap books. His first item, published on December 14, 1933, was entitled "Suit against Quebec engineer dismissed on legal technicality." His last article, published on November 24, 1983, was titled "Canadian rail spending freed up" (LAC 6-66 and 67).

[22] Legget married Lilian Free, the secretary he met at C.S. Meik and Buchanan while working in London, on February 28, 1931. More about their marriage is in Chapter 9.

[23] "Made work" is work that is designed to provide employment, as opposed to work that is necessary. Sometimes it is referred to as "relief work."

[24] The 24-storey Sun Life Building in downtown Montreal was constructed for the Sun Life Insurance Company. It was built in three phases: 1913-1918, 1923-1926 and 1929-1931. When completed, it was the largest building in the British Empire, measured by square footage; however, the neighbouring Royal Bank of Canada office building was taller by several floors (Wikipedia).

Modern photo of the Sun Life Building (photo source Wikipedia)

More about Legget's work at the Sun Life Building is in Chapter 9.

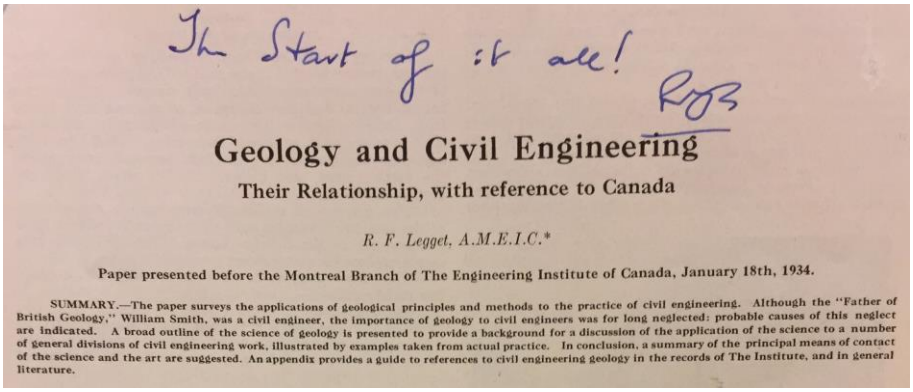
[25] Legget started to work at the Sun Life Building sometime in March 1932 and therefore his meeting with O'Neill occurred at approximately the same time.

[26] John Johnson O'Neill (1886-1966) graduated with a BSc and MSc in geology from McGill University in 1909 and 1910, respectively, and a PhD from Yale in 1912. He joined the faculty of the McGill Geology Department in 1921, became the Chair of the Department in 1929, then Dean of Science in 1935. He took over from Dr. Ernest Brown as Dean of Engineering in 1942 and became Vice Principal in 1948, retiring in 1952 (Wikipedia).

[27] The Engineering Institute of Canada (EIC) was founded in 1887 as the Canadian Society of Civil Engineers (civil, as opposed to military engineers). It changed its name to the Engineering Institute of Canada in 1918 to represent all branches of engineering. It is currently a federation of 12 constituent societies (Engineering Institute of Canada website). There is currently a Canadian Society for Civil Engineering also known by its initials CSCE.

[28] The EIC's *Engineering Journal* was published monthly starting in 1918 and superseded the semi-annual *Transactions of Canadian Society of Civil Engineers* started in 1887. Until the 1960s, when a number of the engineering disciplines left the EIC and started to publish their own journals, the *Engineering Journal* was the prime outlet for publishing engineering papers in Canada. Starting in the mid-1960s, the number of issues per year were reduced until 1987, when it ceased publication (Engineering Institute of Canada website).

[29] The following reprint of Legget's 1934 paper was in the files that he sent to Paul Karrow in 1982. At the time Karrow, a Professor in the Earth Sciences Department at the University of Waterloo, was collaborating with Legget on the textbook *Handbook of Geology in Civil Engineering*, published in 1983.



The Start of it all! RFL

Geology and Civil Engineering

Their Relationship, with reference to Canada

*R. F. Legget, A.M.E.I.C.**

Paper presented before the Montreal Branch of The Engineering Institute of Canada, January 18th, 1934.

SUMMARY.—The paper surveys the applications of geological principles and methods to the practice of civil engineering. Although the "Father of British Geology," William Smith, was a civil engineer, the importance of geology to civil engineers was for long neglected: probable causes of this neglect are indicated. A broad outline of the science of geology is presented to provide a background for a discussion of the application of the science to a number of general divisions of civil engineering work, illustrated by examples taken from actual practice. In conclusion, a summary of the principal means of contact of the science and the art are suggested. An appendix provides a guide to references to civil engineering geology in the records of The Institute, and in general literature.

From the first page of the paper. At the top Legget wrote "The Start of it all! RFL" It's not known when he wrote these words. (OUIT Archives)

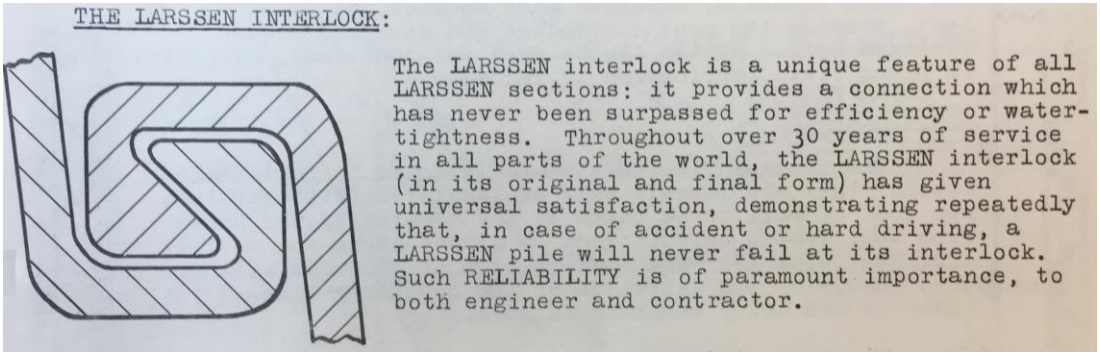
[30] Today the Athenaeum is a five-star hotel in the Piccadilly area of London. It was built as Hope House in the mid-1800s and when Legget visited it in the 1930s, it would have been a distinctive art deco apartment building with its own restaurant (Wikipedia).

[31] McGraw-Hill Publishing Company is a New York-based university and professional book publisher that has roots back to 1888 (Wikipedia). Legget published a number of books with McGraw-Hill.

[32] Legget is referring to his now classic 650-page textbook, *Geology and Engineering,* published by McGraw-Hill in 1939.

[33] The British Steel Piling Company Ltd. was founded in 1905. The company was acquired by Tex Holdings PLC in 1989 and is based in Great Blakenham, near Ipswich, England, where it established its manufacturing centre in 1921 (British Steel Piling Company website).

[34] Larssen sheet piling was developed in 1902 by Tryggve Larssen, a government surveyor in Bremen, Germany, for use in the construction of the waterfront structure in Bremen. It is manufactured from rolled sheets of steel that are bent into a channel-shaped cross-section with a system to interlock the piles together.



THE LARSSEN INTERLOCK:

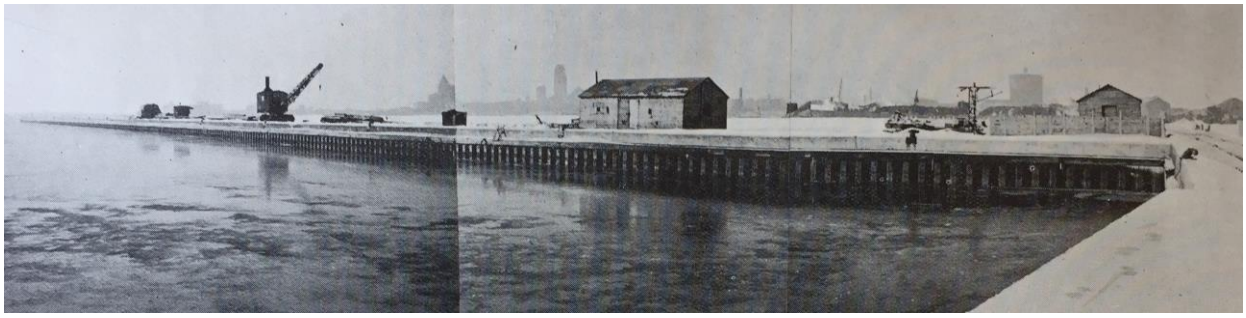
The LARSSEN interlock is a unique feature of all LARSSEN sections: it provides a connection which has never been surpassed for efficiency or water-tightness. Throughout over 30 years of service in all parts of the world, the LARSSEN interlock (in its original and final form) has given universal satisfaction, demonstrating repeatedly that, in case of accident or hard driving, a LARSSEN pile will never fail at its interlock. Such RELIABILITY is of paramount importance, to both engineer and contractor.

Description of the Larssen interlocking system from a 1935 company publication written by Legget (LAC 9-27)

The design was originally patented, but the product is currently manufactured by many different companies and used throughout the world. It is still referred to as Larrsen sheet piles.

[35] Legget was based in Montreal when he worked with the British Steel Piling Company Ltd. subsidiary, the Canadian Sheet Piling Co. Ltd.

[36] This project is described more fully in two papers by Legget titled "New Coal Dock for Toronto Harbour," published in *Civil Engineering* (New York), August 1937, pp 284-287, and "Construction Methods for 22 Acre Coal Storage Dock in Toronto," published in *Engineering & Contract Record* (Toronto), August 25, 1937, pp 9-15.



Panorama of the coal dock from Legget's article in *Civil Engineering*.
Larssen sheet piling forms the facing of the dock. (LAC 4-60)

[37] There were two magazines called *Civil Engineering*. One was published in the UK with the full name *Civil Engineering and Public Works Review.* It was published between 1906 and 1973. The other was published in New York and was associated with the American Society of Civil Engineers (ASCE). It was called *Civil Engineering* and was first published in 1930. From Legget's references in his memoir, it is sometimes difficult to know to which magazine he is referring. From the subject matter, this *Civil Engineering* is likely the US magazine.

[38] US Steel was founded in 1901 and at one time was the largest steel manufacturer in the world. In 2016, it had dropped to the 24th largest. Bethlehem Steel was founded in 1904 and was at one time the second largest steel manufacturer in the US. In 2003, the company was dissolved. Both companies were based in Pennsylvania (Wikipedia).

[39] Most readers will know of the 80-km Panama Canal that connects the Pacific and Atlantic oceans. The Kiel Canal is a 98-km canal in northern Germany that connects the North and Baltic seas.

[40] In the late 1800s and early 1900s, the Swedish State Railways started railway construction in that country. A number of landslides occurred as a result of constructing railway embankments on clay. The largest, and perhaps best known, is the 1918 Geta landslide in eastern Sweden that resulted in 41 fatalities. These landslides led to the formation of the Swedish State Railway Geotechnical Commission that submitted its report in 1922. The use of the term "geotechnical" in the name of this commission may be the first use of the term anywhere in the world (Massarsch, K.R. and Fellenius, B.H. 2012. "Early Swedish Contributions to Geotechnical Engineering," ASCE Geo-Institute Geo-Congress Oakland, California, Geotechnical Special Publication 227, pp 239-256).

[41] Legget preferred the term "geotechnique," (the noun as used in the title of his memoir, or "geotechnical," the adjective) rather than "soil mechanics" because geotechnique includes the associated disciplines of geology, hydrogeology and rock mechanics along with soil mechanics.

[42] Arthur Casagrande (1902-1981) was another Austrian Empire-born civil engineer and early geotechnical engineering researcher, practitioner and professor. In the early 1930s, he developed the soil mechanics program at Harvard University. Casagrande was the Organizing Chair and Secretary of the 1936 International Conference (Wikipedia).

[Chapter 8:] FIRST INTERNATIONAL CONFERENCE (1936)

Making every allowance for natural bias, my wife and I still think of this meeting as the most pleasant and rewarding that we have ever attended. There were only 206 present, just the "right number." The programme was well arranged with plenty of time for private talks. There was an atmosphere about the entire week that was exciting, as if we knew instinctively that this really was the start of a new chapter in civil engineering.[1] We were all accommodated on Harvard Yard, and ate in University dining facilities (except for a few special functions).[2] All this led to our making at least fifty good friends there, with whom we kept in touch for many years (in most cases for the rest of their lives, most of them being older than we were). I am tempted to give the full list but this would not be too helpful; instead, let me give the names of those who became very close friends.

Dr. Terzaghi, President of the Conference, for some reason unknown always to us, gave us the gift of his friendship then, and for the rest of his life. Similarly, we got to know Arthur Casagrande and his brother Leo, *[the latter]* then living in Germany. Phil Rutledge[3] was one of Arthur's assistants at Harvard; later we saw much of him and his wife. Practicing engineers, already men of distinction, included Carlton S. Proctor, Admiral Bakenhus (retired US Navy), Lazarus White and his two sons, Robert Ridgeway, F.T. Darrow from Nebraska and H.A Mohr of Boston. Younger men included Earl Bennett, Spencer J. Buchanan (friendship with whom was broken only very recently by his death), Donald Burmister, A.E. Cummings, C.A. Hogentogler, E.J. Kilcawley, D.P. Krynine (at Yale), J.O. Osterberg M.G. Spangler, O.L. Stokstad, Donald Taylor and E.W. Vaughan (of TVA).[4] Many of these names will be recognised from their later contributions to the literature.[5] One US name I have left for special mention, Bill Housel; we "hit it off" straightaway with him and his wife but even at this meeting, the antipathy between him and Arthur Casagrande, which was so unfortunate, was already evident; and yet Bill, despite some of his unusual ideas, <u>was</u> one of the soil pioneers of this continent.[6]

From overseas there were Paul Raes, of Ghent, Belgium,[7] (who stayed with us in Montreal after the meeting to see how a bilingual society worked, and who became a very close friend), Rudolph Tillman the City Engineer of Vienna (who wanted to know what a bulldozer was, for a dictionary one of his friends was preparing; so I photographed him with one on the big field trip), Drs. Hanna and Tschebotarioff[8] then both from Egypt, Len Cooling from the UK (the start of a close link[9]), Bax-Steevens from the Netherlands East Indies[10] (imprisoned, with all his family, in different camps for the whole of the *[Second World War]* by the Japanese), and J.J. Bryan from the Straits Settlements, then under the UK.[11] From these short lists (and they are far from complete), it can be gathered that the United States, contributed about two thirds of those attending. What of the Canadians?

Eight Canadians were listed, six certainly attended. From the Department of Public Works,

Canada, came *[Harold]* M. Davy, long-time head of their test-drilling unit, and Jack Lucas at the start of his work in their testing laboratory; from Universities, Dr. C.R. Young,[12] then head of the Department of Civil Engineering at the University of Toronto (later to be Dean), Professor I.F. Morrison[13] of the University of Alberta, and from *[the University of]* Saskatchewan, Professor G.M. Williams.[14]

(None of us ever saw Prof. Williams, but he was a shy man and may have kept to himself; he maintained some sort of residence or link with the United States all the time he was at UofS.) From construction came R.J. Mattson, a dour Scandinavian who was an office engineer with the Foundation Company of Canada,[15] a quite delightful chap once you got to know him even though he had no sense of humour whatever, and was the greatest "squirrel" for trade literature that I have ever met! He had been sent to the meeting by the President of his Company, "the Chief," Mr. R.E. Chadwick,[16] one of Canada's all-time construction "greats." We[17] both have the impression, still, that the Chief did turn up at the meeting, maybe for just a day, but his lively interest in Soil Mechanics was already there, in keeping with his forward-looking outlook. And, somewhat to our surprise, J.M.R. Fairbairn, the great Chief Engineer of the Canadian Pacific Railway was listed as an attendee, even though neither of us can recall seeing him there.[18] But his interest, expressed in his registration, is yet another indication of the truly great men who were the leaders of Canadian civil engineering in those days of such keen development.

And we brought up the tail end *[of Canadians]*. I had known Harold Davy, Jack Lucas and Mattson previously, and had met "the Chief" and Mr. Fairbairn (both most kindly to me as a youngster), but the meeting gave me (I am almost sure) my first meeting with "C.R." Young, and certainly so with I.F. Morrison—so greatly to my lasting pleasure, until his death [*in 1958]*.

The technical proceedings of the Conference are available for all to see in the three volumes of Proceedings (reprinted at Harvard in 1965[19]) but it may be convenient if I include as an appendix to *[this memoir]* a copy of the account I wrote for the *Engineering Journal;* [A] it will be found *[in Chapter 18, Appendix A]*. When I look at this today, I am concerned to find no names of fellow Canadians listed; I feel sure that these were in my original account but it was "boiled down" somewhat by the Editor, as noted in the heading.[20] This account gives (I think) a good general idea of the technical content of the Conference; let me add just a few notes about the more personal aspect of it.

The registration fee was only $10[21] for everything, accommodation in The Yard[22] being gratis! The total cost of the meeting *[for the organizers]*, including the initial printing of the proceedings, was only $7,208, of which sum Harvard University paid over $3,000 from their Tercentenary account, since the Conference was a part of the summer-long celebration of the 300th anniversary of the great University.

The initial notices said that foreign guests would be received in New York—so I naturally

[A] Legget R.F. (1936). "The First International Conference on Soil Mechanics," *Engineering Journal*, Vol 19, pp 389-391.

asked *[Arthur Casagrande]* if we could be classed as Foreign guests! He agreed, for this part of the meeting only! So we travelled to New York, stayed at the Sheldon Hotel[23] with all the others, were welcomed at a cocktail party on the 64th floor of the RCA Building, followed by a fine dinner in the Rainbow Grill.[24] On the day following (Saturday) we were all taken by bus on a fine tour climaxed by a visit to West Point,[25] my wife being taken by Mrs. Robert Ridgeway in the lead car, following a motorcycle escort which went through every red light. To the amazement of most of the visitors—even to us, it was a thrilling ride! On the Sunday, a special *[rail]*car had been arranged for us on the 3:00 pm train to Boston on the New Haven *[Rail]*line; we sat with the Bax-Steevens, and so began one of our valued friendships.

The meeting started on the Monday and lasted all week, finishing with a fine field trip, all-day, to the Quabbin water supply scheme for Boston,[26] then under construction. And the ending was a memorable dinner at Longfellow's Wayside Inn (since burned).[27]

What did Canada contribute to the Conference? It is a measure of the stature of "C.R." Young that he was asked to preside over the final session at which resolutions—of thanks, and of a desire for a continuation of the conferences—were unanimously adopted. (Unanimously, apart only from one opposing vote to the resolution about continuing the conferences; for the life of me I can not now recall who this was!). In the third volume *[of the proceedings]* there are two contributions to the discussions—a listing of British publications on pile driving and the supporting power of piles, and another on British publications on lateral earth pressures, both of which I was asked to contribute.[B]

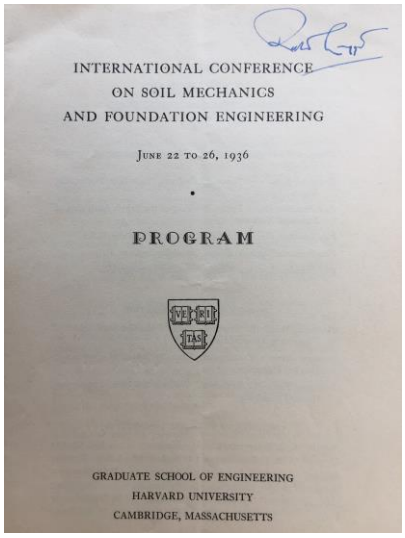
There is only one Canadian paper in the other two volumes,[C] [28] and I wish there wasn't! It was a summary of one I had prepared, but it is really a most amateurish effort; I was ashamed of it when I saw the calibre of some of the other papers. All I can say of it is that it did indicate Canadian interest, even if it also showed the abysmal ignorance of one Canadian. I hope that no reader of these words will ever look at it.

[B] Discussions are in Vol 3 *[of the Proceedings]*, pp 142-143 and 160.

[C] Legget, R.F. (1936). "The Correlation of Soil Mechanics Studies with the Design and Construction of Retaining Walls," *Proceedings* of the International Conference on Soil Mechanics and Foundation Engineering, Vol 1, pp 207-211.

Annotations Chapter 8: FIRST INTERNATIONAL CONFERENCE (1936)

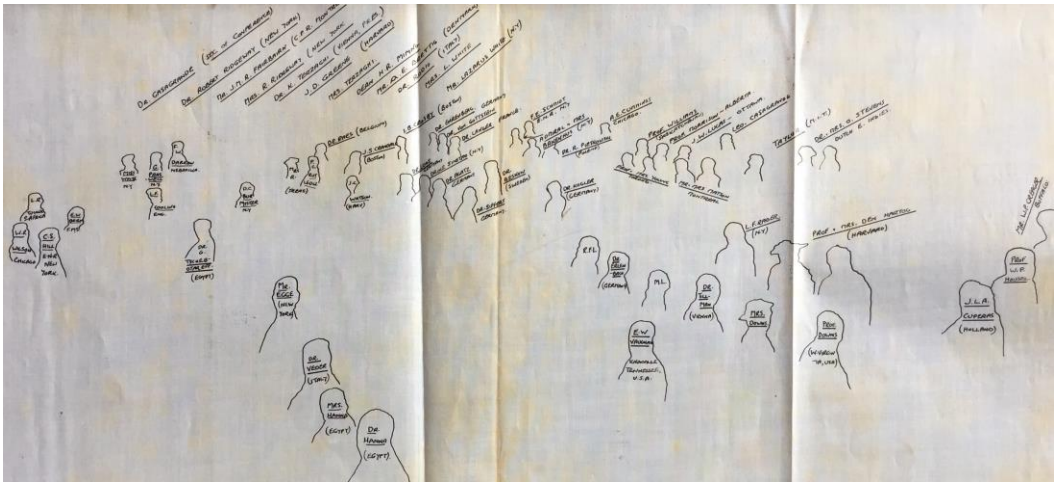
[1] From the 1936 International Conference on Soil Mechanics and Foundation Engineering.



Legget's copy of the program and his name badge (LAC 19-16)

[2] Photo of the "Welcome Dinner, International Conference on Soil Mechanics and Foundation Engineering, Harvard University – June 22-26, 1936."

Legget is near the middle of the photo, on the left side at the far end of the lower series of tables, third table from the left. Mrs. Legget is the second person to his right. (LAC Spec Coll)



A transparency in Legget's files that identifies a number of the delegates at the Welcome Dinner. The organizers and dignitaries, standing at the back of the photo, are identified as: "Dr. Casagrande (Sec. of Conference); Dr. Robert Ridgeway (New York); Mr. J.M.R. Fairbairn (C.P.R. Montreal); Mrs. R. Ridgeway (New York); Dr. K. Terzaghi (Vienna, Pres.); J.D. Greene (Harvard); Mrs. Terzaghi; Dean H.R. Mimno; Mr. A.E. Bretting (Denmark); Dr. Rodio (Italy); Mrs. L. White, Mr. Lazarus White (N.Y.)" (LAC Spec Coll)

[3] Philip Casteen Rutledge (1906-1990) was a civil engineer (BSc, Harvard 1927; MS, MIT 1933 and DSc, Harvard 1939) who helped Arthur Casagrande organize the conference. He taught at Purdue University (1937-1943) and Northwestern University (1943-1952). During the Second World War he helped develop airfield pavements for heavy wartime aircraft. In 1952, he helped establish the New York consulting firm Mueser Rutledge and was known for his foundation designs for buildings, bridges, dams, industrial plants and waterfront structures. He retired in 1977 (US National Academy of Engineering website).

[4] TVA is the Tennessee Valley Authority, a US agency that provides electricity, flood control, navigation and land management for the Tennessee River System (Tennessee Valley Authority website).

[5] The following paragraphs provide a little more information on some of the individuals mentioned in Legget's memoir:

Carlton S. Proctor (1894-1970) worked for the New York-based engineering consulting firm Proctor, Mueser, Rutledge & Johnston. That firm provided the foundation designs for many US dams, bridges and buildings, including the George Washington and Golden Gate bridges, the United Nations building and Yankee Stadium (New York Time Obituaries website).

Carlton Proctor is not the individual who developed the Proctor Compaction Test. The compaction test is named for Ralph R. Proctor.

Reuban Edwin Bakenhus (born 1873) worked as a civil engineer in various US Navy shipyards on the east coast and attained the rank of Rear Admiral. He retired in 1937 (US Navy History website).

Lazarus White (born 1874) worked as a civil engineer for the New York Rapid Transit Commission and Board of Water Supply before becoming a consulting engineer. He was President of Spencer, White and Prentis from 1919-1950 (Prebook website). He and his wife are standing as dignitaries in the Welcome Dinner photo.

Robert Ridgeway (also spelled Ridgway) (1862-1938) was a civil engineer who did not study engineering but worked 49 years for New York City in construction and became Chief Engineer of the New York Transit Commission in 1921. He became President of the American Society of Civil Engineers in 1925 (Wikipedia). He and his wife are standing as dignitaries in the Welcome Dinner photo.

Harry A. Mohr. In the early 1900s, the first soil penetration test was developed in Boston by Gow Construction Co. In the late 1920s and early 1930s, Mohr helped standardize the test and during the 1940s, in conjunction with Terzaghi, he finalized his development of the Standard Penetration Test (SPT) (Wikipedia).

Harry Mohr is not the individual for whom the Mohr Circle is named. That individual is German civil engineer Otto Mohr.

Spencer J. Buchanan (1904-1982) established soil mechanics at Texas A&M, College Station, in 1946. He was also president of the consulting firm Spencer J. Buchanan & Associates (Texas A&M website).

Donald Burmister was a professor at Columbia University, New York, who correlated standard penetration test blow counts with those of other sampler blow counts, using input energy corrections. He is also known for his work on soil classification (Wikipedia).

A.E. Cummings was Director of Research of the Raymond Concrete Pile Company, New York. He was also the author of *Pile Foundations,* a 34-page 1952 reprint of a September 1940 article on concrete pile foundations, originally published in *Proceedings of the Purdue Conference on Soil Mechanics and Its Application*, Purdue University, Lafayette, IN (Amazon.com). Legget attended this 1940 conference.

C.A. Hogentogler was a senior highway engineer with the US Bureau of Public Roads and the first Chairman of ASTM Committee D18 on Soil and Rock for Engineering Purposes. He authored *Engineering Properties of Soils,* published by McGraw-Hill in 1936. The ASTM's C.A. Hogentogler Award is named in his honour. His son formed Hogentogler & Co in 1939, first as an engineering consulting firm. The firm then started manufacturing materials testing equipment to meet the standards developed by his father and others on the ASTM committee.

E.J. Kilcawley was the head of soil mechanics at Rensselaer Polytechnic Institute, Troy, NY, and author of *Weathering Resistance of Concrete* (Amazon.com).

D.P. Krynine was a professor at Yale University, New Haven, CT. He was co-author, with W.R. Judd, of the 1957 textbook, *Principles of Engineering Geology and Geotechnics*, published by McGraw-Hill.

Jorj O. Osterberg (1915-2008) was a 1940 graduate of Harvard University under Arthur Casagrande. He invented the WES (Waterways Experimental Station) pressure cell, the Osterberg piston sampler and the Osterberg drilled shaft load cell (O-cell). He started the soil mechanics laboratory at Northwestern University, Evanston, IL (US National Academy of Engineering website).

Merlin Grant Spangler (1894-1986) was a professor at Iowa State College and author of the 1951 textbook *Soil Engineering*, published by International Textbook Co (Babal Hathitrust website). He is known for his work on culvert theory.

O.L. Stokstad was a soils engineer with the Michigan State Highways Department.

Donald W. Taylor (1900-1955) was a graduate of MIT, Cambridge, MA, where he was on staff, then faculty, from 1936. He authored the 1948 textbook *Fundamentals of Soil Mechanics*, published by John Wiley & Sons. Among other things, Taylor is also known for the Taylor's Stability Charts.

[6] William (Bill) S. Housel (1901-1978) was a professor at University of Michigan, Ann Arbor, research consultant to the Michigan Department of State Highways and private consultant. He made significant contributions to the design and testing of deep foundations and was a founding member of ASTM Committee D18 on Soil and Rock for Engineering Purposes (Google Books).

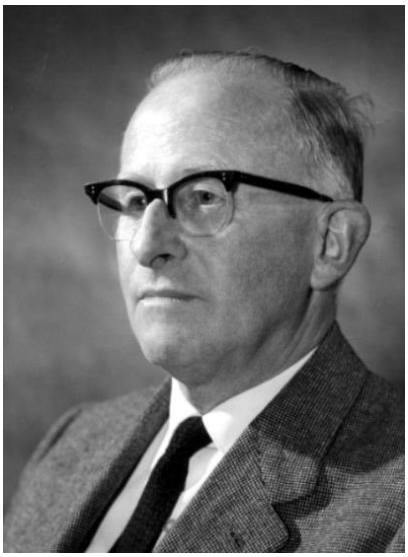
[7] Paul Raes was at the University of Ghent, Belgium. He attended the conference with the financial assistance of the Belgium American Educational Foundation Inc.

[8] William S. Hanna (1896-1980) was an Egyptian-born, long time faculty member of Fouad El-Away University (now Cairo University). In 1933 he established the first soil mechanics laboratory in Egypt and is considered the Father of Egyptian Soil Mechanics (Wikipedia).

Gregory P. Tschebotarioff (1899-1985) was a Russian-born and Russian- and German-trained civil engineer who worked in Germany and Egypt before joining the faculty at Princeton University, Princeton, NJ, in 1938. He started Princeton's soil mechanics program. He was author of, among many other publications, the 1973 textbook *Foundations, Retaining and Earth Structures*, published by McGraw-Hill (Wikipedia).

[9] Leonard Frank Cooling (1903-1977) was Head of the Soil Mechanics Section of the British Building

Research Station. A soil physics section was established in 1933 and Cooling was put in charge. He then established the first soil mechanics laboratory in Britain. In 1935, the section was renamed the Soil Mechanics Section. Among other accomplishments, Cooling was one of the founders of the journal *Géotechnique* in the late 1940s (Burland, J.B. 2008. "The Founders of *Géotechnique," Géotechnique,* Vol 58, pp 327-341.)



Dr. Leonard Frank Cooling (photo source Burland, 2008)

Legget relates more about Cooling later in his memoir. Two prominent Canadian geotechnical engineers worked under Cooling early in their careers before immigrating to Canada: Geoffrey Meyerhof and Hugh Golder.

[10] The Netherlands East Indies is more commonly referred to as the Dutch East Indies. It was a Dutch colony until the 1949 when it became Indonesia. The entire colony was occupied by the Japanese during the Second World War, from late 1941 to the end of the war in the Pacific, September 2, 1945 (Wikipedia).

[11] The Straits Settlements originally consisted of four individual "settlements," Penang, Singapore, Malacca and Dinding. Christmas Island and the Cocos Islands were added in 1886. The island of Labuan, off the coast of Borneo, joined in 1912. Most of the territories now form part of Malaysia, from which Singapore separated in 1965. The Cocos (or Keeling) Islands were transferred to Australian control in 1955 and Christmas Island was transferred to Australia in 1958 (Wikipedia).

[12] Clarence Richard Young (1879-1964) started teaching structural engineering in the Department of Civil Engineering at the University of Toronto in 1908, was Head of the Municipal and Structural Division of the department from 1929 to 1945 and was Dean of Applied Science and Engineering from 1941 to 1949. He contributed to the Toronto Building Code. After retirement Young wrote about early engineering education at the university (White 2000). Legget relates more about Young later in his memoir.

[13] Ibrahim Folinsbee Morrison (1889-1958) was American-born and MIT-trained. He joined the Civil and Municipal Engineering Department, University of Alberta in 1912. The 1936 conference seems to have been the impetus that accelerated the development of soil mechanics at U of A. See also Morrison 1997.

[14] G.M. Williams, Professor of Civil Engineering at the University of Saskatchewan, should not be confused with G.B. Williams of the Manitoba Department of Public Works who is mentioned later in Legget's memoir.

[15] From 1910 to 1924, this company was a subsidiary of the US firm Foundation Company. In 1929 it became the Foundation Company of Canada, the independence of it having been initiated in 1924.

[16] Richard Ellard Chadwick (1885-1966) was President of the Foundation Company of Canada from 1924 to 1952 (CGS website; Lives Lived).

[17] Here and later in this chapter, Legget is referring to himself and his wife, who also attended the conference.

[18] In 1983, Legget and his wife may not have remembered J.M.R. Fairbairn attending the conference, but Legget's transparency of those who attended the Welcome Dinner identifies Fairbairn. Besides being the Chief Engineer of the Canadian Pacific Railway in the mid-1920s, Fairburn was involved in the founding of the "ritual of the calling of an engineer" (Wikipedia).

Mrs. Mary Legget (centre) flanked by delegate Dr. O. Stevens and his daughter, from the Dutch East Indies. Photo by Legget (LAC 19-16)

[19] Since 2017, all ISSMFE and ISSMGE proceedings have been available online. See Chapter 24.

[20] The "heading" Legget refers to is just below the title of his contribution "(Abstract of a report contributed by R.F. Legget, AMEIC [Associate Member of the Engineering Institute of Canada])." It is difficult to understand why the editors of the Canadian-published *Engineering Journal* would, as Legget suggests, remove the names of the Canadian delegates.

[21] $10 in 1936 would be approximately CDN$200 in 2020.

[22] "The Yard" is Harvard Yard, the oldest part of Harvard University and the location of the dormitories for most freshmen.

[23] The Sheldon Hotel, completed in 1923, was originally a men's residence. At that time, it was considered the tallest hotel in the world. The 31-storey building was designed in the Romanesque Revival style and is thought to have influenced the design of the later-built Empire State Building. Today it is the New York Marriott East Side Hotel and a New York landmark (New York City Archives website).

[24] The Rainbow Grill is located on the 65th floor of what was originally known as the RCA Building, now the Comcast Building, at 30 Rockefeller Plaza. The building was completed and the restaurant opened in 1934 (only two years before Legget's visit) as a "focal point for the city's elite." The building and the restaurant are New York landmarks (Wikipedia).

[25] West Point, established in 1802, is a prestigious US Military Academy located approximately 80 km north of New York City (Wikipedia).

[26] The Quabbin water supply scheme, now referred to as the Quabbin Reservoir, was created between 1930 and 1939 and is the largest inland body of water in Massachusetts. It is the primary water supply for Boston, approximately 100 km to the east (Wikipedia).

[27] Longfellow's Wayside Inn, located approximately 40 km west of Boston, began as Howe's Tavern in 1716. When Henry Wadsworth Longfellow visited it in 1862, he wrote a series of poems that focused on

the tavern. It was given its current name in 1892. As Legget mentions in his memoir, a fire in 1955 destroyed most of the inn, but it was fully restored by 1960, the year it became a US National Historic Site (Wikipedia).

[28] In Legget's files in the Library and Archives Canada, there are copies of approximately 300 papers and articles that he authored or co-authored between 1923 and 1993 (LAC 4-4 to 6-65). His paper in Volume 1 of the *Proceedings of the 1936 International Conference* is not among them, possibly indicating how little he thought of it. A copy of the manuscript of his paper, however, is elsewhere in his files (LAC 9-28).

Chapter 9: EARLY YEARS IN CANADA (1929-1936)

When Legget immigrated to Canada, his planned destination was Montreal. It was the economic and cultural centre of Canada during the 1800s and into the first half of the 1900s. In 1930, the population of Montreal was approximately 800,000, compared to Toronto's 600,000. Montreal was the headquarters of many of Canada's larger companies, including most of Canada's engineering companies. Montreal was where many larger international companies established their footholds in Canada. For Legget, it was a logical place to go.

When he arrived in Montreal in April 1929, Legget contacted the local branch of Toc:H[1] and through that organization met many Canadians and immigrants who helped him find his way around the city.

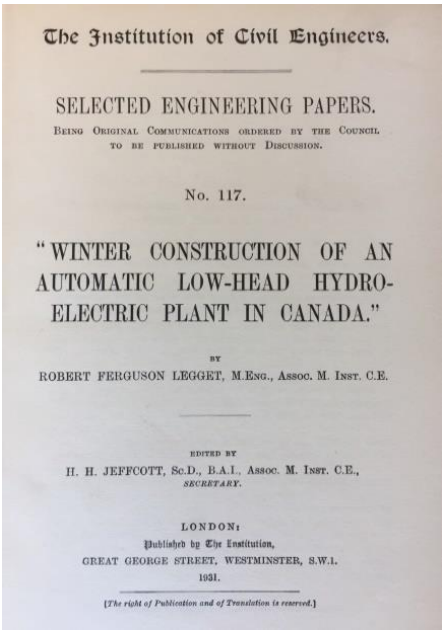
He continued to join engineering associations. In 1929, he became a member of the Corporation of Professional Engineers of Quebec (now the Ordre des ingénieurs du Québec). In 1930, he became an Associate Member of the (UK) Institution of Civil Engineers. In 1931, he became an Associate Member of the Engineering Institute of Canada.

Within three months of his arrival in Montreal, he joined the Power Corporation of Canada and was off to northern Ontario and the Upper Notch Hydroelectric Power project. This was a wonderful experience for Legget. As he had done previously for two other major experiences in his life, he created a bound journal. It is a fully annotated description of the project with some personal notes and photos (LAC Spec Coll).

Left: a page from Legget's Upper Notch Plant journal, written and compiled in 1931. Right: photo taken in 1930 during construction of the Upper Notch plant. Legget is third from left. The other men are not identified, but one is possibly D. Hutchinson, Construction Superintendent. (LAC Spec Coll)

In early 1931, shortly after his return from northern Ontario to Montreal, Legget prepared several papers and articles about the Upper Notch project. Besides the article for the *Engineering News-Record,* which he mentions in his memoir, he published a 26-page paper for the Liverpool Engineering Society, a short article for *Contractors and Engineers Monthly*[2] and his first contribution to the *Engineering Journal.*[3] Legget's most significant summary of the project

was a 23-page paper for the (UK) Institution of Civil Engineers, titled "Winter Construction of an Automatic Low-Head Hydro-Electric Plant in Canada," for which he also compiled an unpublished folio of photographs. Legget won awards from the Liverpool Engineering Society and the Institution of Civil Engineers for his contributions to these respective associations.



The Institution of Civil Engineers.

SELECTED ENGINEERING PAPERS.

BEING ORIGINAL COMMUNICATIONS ORDERED BY THE COUNCIL TO BE PUBLISHED WITHOUT DISCUSSION.

No. 117.

"WINTER CONSTRUCTION OF AN AUTOMATIC LOW-HEAD HYDRO-ELECTRIC PLANT IN CANADA."

BY

ROBERT FERGUSON LEGGET, M.ENG., ASSOC. M. INST. C.E.

EDITED BY

H. H. JEFFCOTT, SC.D., B.A.I., ASSOC. M. INST. C.E., *SECRETARY.*

LONDON:

Published by The Institution,

GREAT GEORGE STREET, WESTMINSTER, S.W.1.

1931.

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Cover of Legget's 23-page paper for the Institution for Civil Engineers (LAC 4 12)

In February 1931, before the above project-related papers were published, Legget published a forward-looking article in the *Journal of the University of Liverpool Engineering Society* that he may have written while working in northern Ontario. It was titled "An Awakening, a note on the Aeroplane and Engineering in Canada."[4]

Later that month Legget left the single life behind. On February 28, 1931, he married Lilian Free, the secretary whom he had met while working for C.S. Meik and Buchanan in London. In an unpublished note written in 1984,[5] Legget describes the lead up to, and his marriage.

> Once I was established in Canada, it did not take me long to realize that Miss Free was, for me, rather more than the girl in the front office. I proposed, in a way, by letter. As soon as the Upper Notch job was complete and handed over to the operating Company, I sailed for England (at the end of January 1931) and in the course of one month in the United Kingdom got formally married to Miss Free; we were married in St. John's Church in Stratford, London….we spent our honeymoon by sleeping in seven beds on eight nights; and then sailed off back to Canada [where] we 'have lived happily ever after'—now for fifty three years.

Lilian Free was born in 1900 (four years before Legget) in Dagenham, Essex County, England, approximately 20 km east of London. She joined C.S. Meik and Buchanan in 1924. Legget continues that Lillian Free:

> …succeeded the first Secretary employed by the Firm who had resigned/retired(?). This first Secretary (whose surname we can not recall) was named Mary. Mr. Morris [the front

> office Manager], having accepted the 'impossible' by having a woman in the office, told Miss Free that he couldn't possibly learn another girl's name so that she would have to be Mary too. The name stuck.

Lilian would continue to be known as Mary to Legget and to all who knew her on a first name basis, although to most Mary was more formally known as Mrs. Legget.

In early 1932, Legget was laid off from the Power Corporation due to the Depression. He found a temporary position in Montreal working for the Resident Engineer of the Sun Life Building.

The following is how he summarized his work at the Sun Life Building:[6]

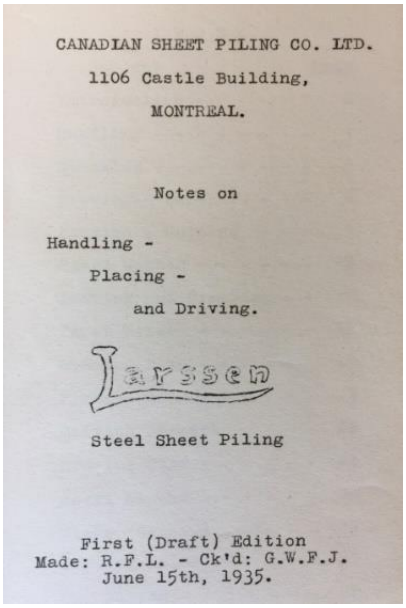
> Seven months in 1932, from March until October, were spent as special assistant to the Resident Engineer in charge of the Sun Life Building, Montreal. This is [when these notes were written] the largest office building in the British Empire, and one of the largest in the world; it had just been completed in its final state, which will enable it to house 10,000 workers. Special work consisted in organizing an adequate costing system for the building operation; complete organization of the building operating staff (numbering about 200), and general administrative duties in connection with building operation.

While working at the Sun Life Building, Legget started working on his Engineering Institute of Canada presentation on "Geology and Engineering," which he refers to in his memoir (see Chapter 7) and would give in January 1934. During the same period he also published two articles on eastern Canadian hydroelectric power projects: Chats Falls, just west of Ottawa, and Beauharnois, just west of Montreal, as well as two more railway articles.

Starting in October 1932 and for the next four years, Legget worked for the Canadian Sheet Piling Co Ltd, the subsidiary of British Sheet Piling Co Ltd. In addition to what he wrote in his memoir, he described his work experience as follows:[7]

> 1932-1936: Engineer to the Canadian Sheet Piling Co. Limited which supplied for Canadian use, British rolled Larssen steel sheet piling. Work included: development work in promoting the permanent use of steel piling in Canadian civil engineering construction; preparation of over one hundred designs for engineers, yearly, for piling structures of varied types; supervision of installation of piling supplied by the Company (on well over 100 contracts).
>
> Territory covered personally included all of Canada east of Winnipeg, in which area repeated visits were paid, and all major civil engineering works in progress were visited. Personal contact was maintained with Dominion Government Departmental Chief Engineers, District Engineers, and many Provincial Government Engineers.

For the company, he wrote a small booklet on the appropriate techniques for handling, placing and driving Larssen steel sheet piles.


CANADIAN SHEET PILING CO. LTD.
1106 Castle Building,
MONTREAL.

Notes on

Handling -
Placing -
and Driving.

Larssen

Steel Sheet Piling

First (Draft) Edition
Made: R.F.L. - Ck'd: G.W.F.J.
June 15th, 1935.

Cover of booklet written by Legget (LAC 9-26)

Developing into a compulsive writer during his four years with Canadian Sheet Piling, Legget wrote 12 articles on various construction projects and associated engineering techniques (including sheet piling), five articles on the engineering profession in general and one additional article on hydroelectric power. These were published in various Canadian, US and UK engineering magazines. He also wrote five more railway articles and a general interest article titled “The Professions and Parliament”, his first general interest article since immigrating to Canada and his first article published in *Canadian Forum.*[8]

In 1933, Legget drafted an outline for a seven-chapter textbook simply called *Power*, his main topic of interest at that time. He did nothing further on this book until the mid-1940s when, while on the faculty at the University of Toronto, he wrote almost 100 pages of the text. By this time its chapters included: “The Age of Power, Animal Power, Wind Power, Water Power, Power from Fuel (Steam), Power from Fuel (Internal Combustion), Tidal and Wave Power, Unusual Sources of Power, and Distribution of Power.”[9] This manuscript was never completed.

In 1936, he wrote his 23-page paper on “The Correlation of Soil Mechanics Studies with the Design and Construction of Retaining Walls” for the International Conference on Soil Mechanics and Foundation Engineering, which he discusses in his memoir (see Chapter 8). Shortly thereafter, he published a paper with a similar title in *The Canadian Engineer*, “A Weekly Paper for Civil Engineers and Contractors.”

In his memoir, Legget mentions he was not terribly proud of his conference paper. *The Canadian Engineer* paper is prefaced with an editor’s note that substantiates this:[10]

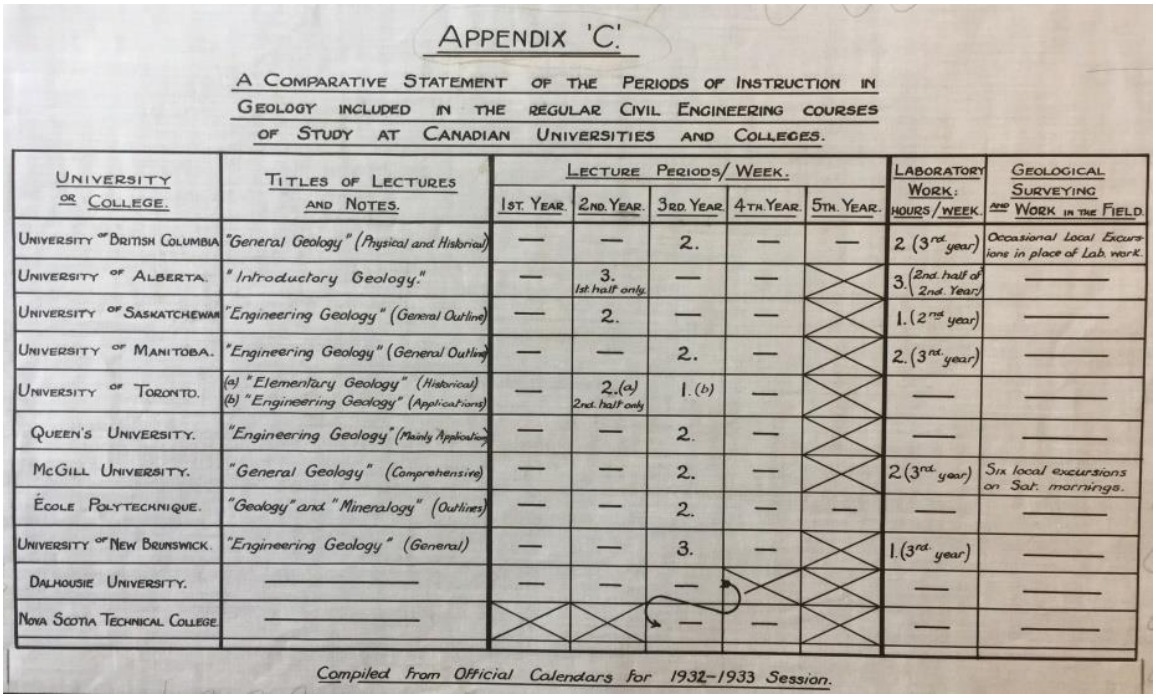
> The following is an abstract of the only Canadian paper presented to the recent First International Conference on Soil Mechanics and Foundation Engineering at Harvard University in June of last year. The author, in agreeing to our request regarding publication of this abstract, wishes us to point out that his paper was prepared solely as a basis for discussion and that it is not a finished technical contribution in the usual sense, features of

which are naturally reflected in the abstract now given—Editor.

Following the conference he wrote two reports on technical aspects of the conference, one published in (US) *Civil Engineering* and one in the *Engineering Journal*. He included a copy of the latter in his memoir as Appendix A (see Chapter 18).[11]

Legget's most important publication in the period from 1929 to 1936 was his paper "Geology and Civil Engineering: their Relationship with Reference to Canada." As described in his memoir, this was published in the October 1934 issue of the *Engineering Journal* and was based on his January 1934 presentation to the Montreal Branch of the Engineering Institute of Canada. It was his first contribution to the geotechnical literature.

As part of his research for his presentation and paper, he surveyed all Canadian universities that taught civil engineering to find out to what extent geology was being taught as part of the civil engineering curriculum, as it had been at his *alma mater*, the University of Liverpool. He presented his results as a hand-drafted table in his paper.



APPENDIX 'C'.

A COMPARATIVE STATEMENT OF THE PERIODS OF INSTRUCTION IN GEOLOGY INCLUDED IN THE REGULAR CIVIL ENGINEERING COURSES OF STUDY AT CANADIAN UNIVERSITIES AND COLLEGES.

UNIVERSITY OR COLLEGE.	TITLES OF LECTURES AND NOTES.	LECTURE PERIODS/WEEK.					LABORATORY WORK: HOURS/WEEK.	GEOLOGICAL SURVEYING AND WORK IN THE FIELD.
		1ST. YEAR.	2ND. YEAR.	3RD. YEAR.	4TH. YEAR.	5TH. YEAR.		
UNIVERSITY OF BRITISH COLUMBIA	"General Geology" (Physical and Historical)	—	—	2.	—	—	2. (3rd. year)	Occasional Local Excursions in place of Lab. work.
UNIVERSITY OF ALBERTA.	"Introductory Geology."	—	3. 1st half only.	—	—		3. (2nd. half of 2nd. Year)	———
UNIVERSITY OF SASKATCHEWAN	"Engineering Geology" (General Outline)	—	2.	—	—		1. (2nd. year)	———
UNIVERSITY OF MANITOBA.	"Engineering Geology" (General Outline)	—	—	2.	—		2. (3rd. year)	———
UNIVERSITY OF TORONTO.	(a) "Elementary Geology" (Historical) (b) "Engineering Geology" (Applications)	—	2.(a) 2nd. half only	1.(b)	—		—	———
QUEEN'S UNIVERSITY.	"Engineering Geology" (Mainly Applications)	—	—	2.	—		—	———
McGILL UNIVERSITY.	"General Geology" (Comprehensive)	—	—	2.	—		2. (3rd. year)	Six local excursions on Sat. mornings.
ÉCOLE POLYTECHNIQUE.	"Geology" and "Mineralogy" (Outlines)	—	—	2.	—	—	—	———
UNIVERSITY OF NEW BRUNSWICK.	"Engineering Geology" (General)	—	—	3.	—		1. (3rd. year)	———
DALHOUSIE UNIVERSITY.	———	—	—	—			—	———
NOVA SCOTIA TECHNICAL COLLEGE	———			—	—		—	———

Compiled from Official Calendars for 1932–1933 Session.

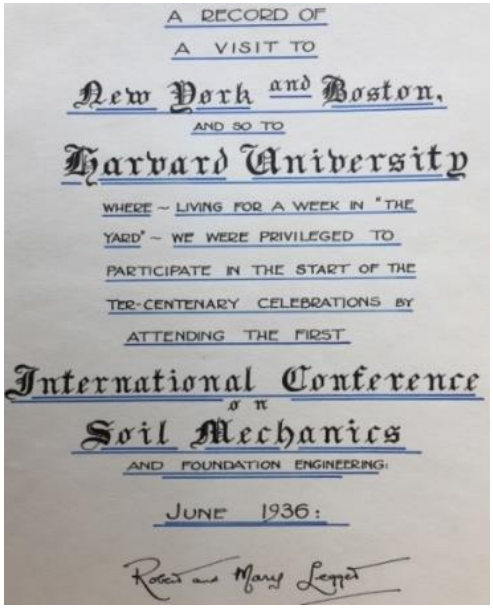
Legget's hand-drafted Appendix C in his 1934 paper "Geology and Civil Engineering" (LAC 10-3)

The 31-year-old Legget followed this presentation and paper by drafting an outline for a textbook on the subject, going to England in the summer of 1935[12] and discussing his outline with Professor Boswell. He then started to write the text and procure the photos and illustrations. The publication of his 650-page textbook *Geology and Engineering*, published in 1939 by McGraw-Hill, will be further discussed in Chapter 13.

A son, David, came into the Leggets' lives in 1934. By then, the Leggets had moved from an apartment on Avebury Avenue in downtown Montreal, to 54th Avenue in Lachine, a suburb approximately 15 km to the west.[13] Undoubtedly, Legget would have commuted by train, his favourite mode of transportation, from Lachine to his Canadian Sheet Piling office on the top floor of the Castle Building at 1410 Stanley Street in Montreal.

2018 photo of the Castle Building that was completed in 1927. It was awarded the Heritage Emeritus Award by the City of Montreal and Heritage Montreal in 2005 (Wikipedia). (photo source Google Maps 2018)

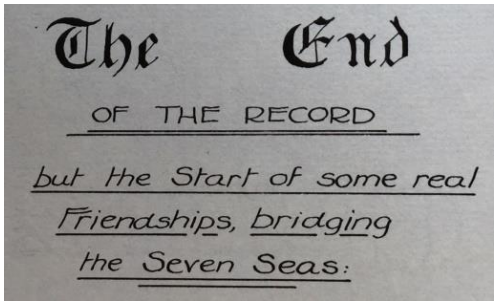
The International Conference on Soil Mechanics and Foundation Engineering in June 1936 at Harvard University had a significant influence on Legget's life and career. As he had done for previous significant, Legget prepared a journal, containing notes, captioned photos and some memorabilia. The photos on the following pages are from that journal.[14]



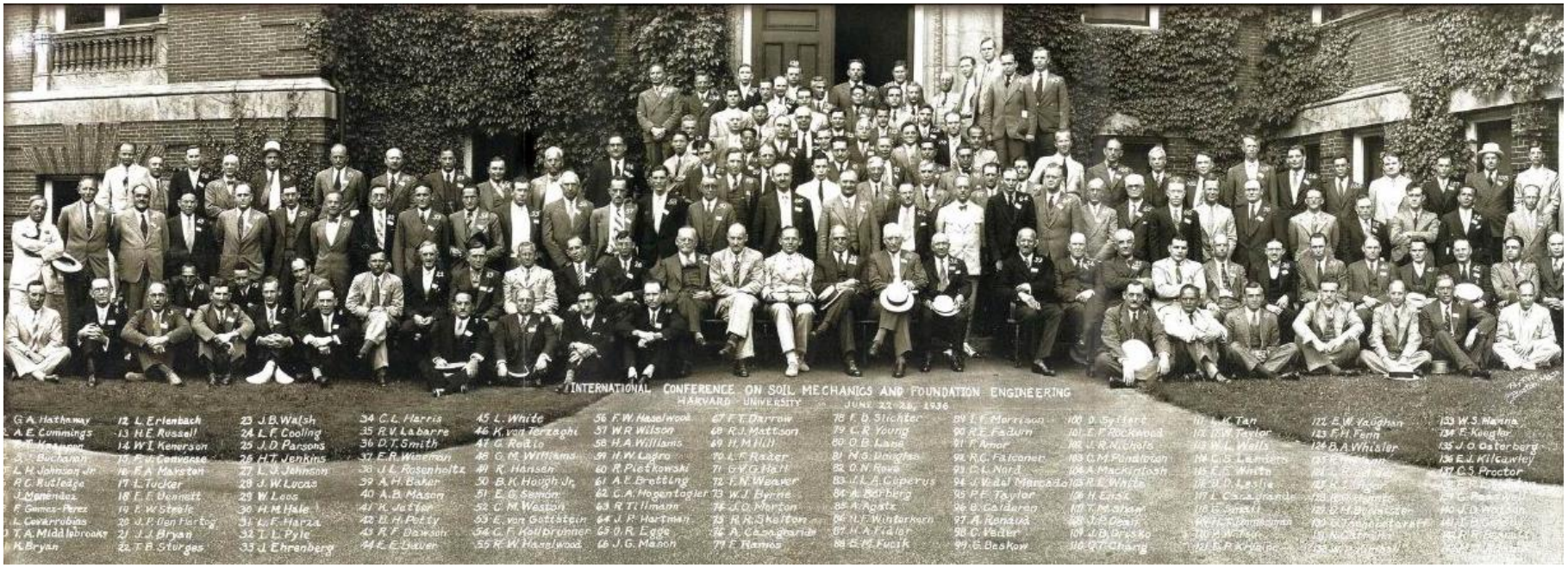
Cover of the journal of the Leggets' trip to the 1936 conference (LAC 19-16)

Two of many photos in the journal. Left: Mary Legget on George Washington Bridge in New York. Note camera in hand. Right: as described in his memoir, Legget became the Montreal correspondent for the *EN-R* in 1933.

The place for this photo in Legget's 1936 journal is empty. In 1977, he removed it from his journal and used it as Figure 1 in his 1977 presentation and the accompanying 1979 paper for his Terzaghi Lecture. The caption in the 1979 paper reads: "FIG 1. Dr. Terzaghi [with cigarette] on Quabbin Dam, Massachusetts, during First International Conference on Soil Mechanics and Foundation Engineering in Summer of 1936. Figures in foreground are Mr. F.E. Schmidt (editor, *Engineering News-Record*) left, and Dr Rudolph Tillman (City Engineer of Vienna, Austria) right)."



The last page of the journal sums up Legget's personal feelings about the conference.



Group photo of delegates to the International Conference on Soil Mechanics and Foundation Engineering, Harvard University, June 22-26, 1936.
In the photo, 143 delegates are shown and identified. Legget is not among them. (photo source ISSMGE)

Annotations Chapter 9: EARLY YEARS IN CANADA (1929-1936)

[1] Toc:H; see Chapter 6 and its annotations

[2] *Contractors and Engineers Monthly* was a US publication first published in 1920. In a 1947 issue, it described itself as “A national business paper for the highway and heavy construction industry.”

[3] “The Upper Notch Automatic Hydro-Electric Plant,” *Engineering Journal*, Vol 14, pp 437-444.

[4] LAC 4-14

[5] “C.S. Meik and Buchanan…Reminiscences 1925-1929,” unpublished note (LAC 9-9)

[6] Queen’s University and NRC Archives

[7] Queen’s University and NRC Archives

[8] *Canadian Forum* was a left-leaning literary, cultural and political monthly magazine, published between 1920 and 2000 (Wikipedia).

[9] LAC 8-22. In addition to the start of this book, Legget’s interest in power is demonstrated by his giving a special lecture at McGill University in February 1934 on “Water Power in Canada (Illustrated)” to the Mechanics’ Institute of Montreal. (LAC 20-3).

[10] LAC 4 49

[11] Legget’s *Engineering Journal* article was published in very small print. To make it more readable, it has been reformatted in Chapter 18 with a larger font.

[12] This 1935 trip to England was associated with his work for the Canadian Sheet Piling Co. It was a trip that lasted several weeks and for which he kept another extensive log—this one handwritten (LAC 2-2).

[13] Both these Montreal area residential sites have since been redeveloped.

[14] LAC 19-16

[Chapter 10:] DEVELOPMENTS IN EASTERN CANADA (1936-1939)

All of us came away *[from the International Conference]* inspired. Professor Morrison[1] returned to the West; I am sure that Dr. Hardy will be recounting his early work.[2] "C.R." Young returned to Toronto, with what results will shortly be seen. Mattson reported to "the Chief" whose interest in the development of Soil Mechanics was thereby assured.[3] The one blank in my memories is what happened in the *[Federal]* Department of Public Works. Harold Davy continued with his test drilling work with little opportunity for "doing anything" about Soil Mechanics, although we certainly talked about it during my occasional meetings with him. I do not know whether Jack Lucas was able to start any laboratory work; he was in the RCAF during the war. Possibly his successor, Norman Laycroft, might know if he could be located. (The DPW Laboratory was abolished a few years ago and Laycroft retired. All my own contacts in DPW have now retired or died and so I have no leads that I can follow up. It might be worth digging into this, although my impression is that *[Jack Lucas]* did not do very much in the way of soil studies.)

In my own case, I returned to my work *[with Canadian Sheet Piling]* with renewed vigour, grateful for being at work in a field of such interest; but long-held thoughts of getting into the teaching of civil engineering were revived. The idea had crossed my mind after some years of experience (after I had come to Canada). Professor O'Neill mentioned it as one way of "sowing seeds" about geology in civil engineering. P.G.H. Boswell added his imprimatur[4] when I asked him on one of my visits to the UK. And an old, wise friend of my Father endorsed the idea also, but got me to promise him that I would not apply for a University post until I had at least ten years of practical experience under my belt.

How wise that advice was I found just as soon as I did start at a University; ten years may be a bit much, but I often wish that I could be dictator and make sure that no University teacher was ever appointed (in any subject) until he has been at work in the "real world" for at least five years.

With this advice behind me, I did not do anything until the spring of 1935 (I graduated in July 1925). I then wrote to all the Deans of Engineering at Canadian Universities and got back kindly replies, all to the same effect–that their University was not yet recruiting any new staff, following the depression years. Some asked me to see them; I recall a delightful talk with Dean Fetherstonhaugh[5] ("Feathers") of the University of Manitoba in his brother's architectural office in Montreal. I knew Dean *[Ernest]* Brown of McGill *[University]*, and had been privileged to meet Dr. *[Frederick]* Sexton, the first President of Nova Scotia *[Technical College]*.[6] I think that I had also met, by then, Professor Earl Turner and the famous "Blinky" Stephens, at *[the University of New Brunswick]*.[7] No luck, so I put the idea out of mind, and "got on with the job."[8]

But after the Conference, we thought it worth trying again, so I wrote again to the ten or eleven engineering schools of Canada, replies were all considerate and kindly but the answer was the same again – No Vacancy. When all the replies were in, my wife and I went for a walk one September evening (in 1936), discussed the future, and decided to put behind us the idea of a university post, starting to plan a future in other directions. We got back to the house and there was a telegram from Dean Clarke at Queen's *[University]* asking me to get into touch with him. (I had been fortunate enough to meet this fine man during the year).

When I called, he told me that they had been inundated with an unexpectedly large second year in engineering and could handle it only if the great Professor "Sandy" Macphail had an assistant.[9] If I was interested, would I come up to Kingston for an interview? I was there the next day (I think); was interviewed by Dr. R.C. Wallace as (I believe) his first official duty as the new Principal;[10] and as a result was offered a job as lecturer at a salary of $1,200 a year, a reflection of the tight control exercised on all Queen's monies by the Treasurer, Dr. McNeill[11] (later a good friend). I said that since I was married with a young son, I could not live on that and so it was graciously increased to $1,800 a year, which I accepted (with my wife's kindly agreement); it was just 50 per cent of my salary from the piling company!

Then followed some hectic days, the term at Queen's about to start, my presence being urgently needed. The President of the piling company was cooperative and let me go with my promise to serve the Company as a consultant in what time I could spare; to the day of his death he regarded me as half-crazy to have given up my good job with him! We found an apartment and within about a week were resident in Kingston. At that time, the Department of Civil Engineering was unique, staffed by four full professors and one lecturer![12] There was an historical explanation of this but I was soon introduced to, and became friends with, Professors Macphail, Wilgar, Ellis and Malcolm, characters all, with Sandy Macphail one of the greatest characters Queen's has ever known, a *[Companion of the Order of St. Michael and St. George]*, friend of Rudyard Kipling, editor of the *Queen's Quarterly*, and the only Professor of General Engineering in Canada![13] (Even mention of his name makes me want to digress; for any interested, I have written up this one episode of my life[A]). Doug Ellis went on to be Dean, always interested in hydraulics. Bill Wilgar retired early (I think) but the soil story takes up again with Lindsay Malcolm.

This fine man entered upon a new lease of life after tragically losing his wife; he became a "workaholic", taking his PhD at Cornell University in Sanitary Engineering at the age of 55, and bestirring the Queen's department in a way never known before. He got funds for building a full-scale sanitary plant, on the waterfront in Kingston, as a research laboratory. He was just setting this up when I arrived. When he heard of my new interest in soils, he generously set aside one room for my use, and this was my first soil mechanics laboratory – started in 1937. It was a slow start, but by early 1938 I was equipped for the simple soil tests and had drawings etc. ready for

[A] Legget R.F. 1971. "Sandy Macphail," *The Queen's Review [May-June, pp. 63-66].*

building equipment necessary for the more important tests already developed, such as soil compaction, and direct shear.

Not too long after I had joined the staff at Queen's I received a very kind letter from C.R. Young, at *[the University of]* Toronto, saying how interested he was that I had entered University work and yet how sorry that he had not been able to entice me to Toronto; an opening was coming up etc. Two letters followed during 1937, in each there was a firm offer of a job in C.R.'s department; to each I replied that I was happy at Queen's etc., with my thanks for the offer. I said nothing to my senior colleagues.

Early in 1938, however, a third offer came from C.R., this one most pressing, with the offer of an Assistant Professorship, responsibility for the course in foundations etc. ... a real "carrot." I was indeed happy at Queen's, already looking forward to staying there a long time; but this letter from C.R. was such that I had to discuss it with Sandy Macphail, telling him (naturally) that it was the *[fourth letter I had received]*. Looking over his half-moon spectacles, Sandy said, in his own inimitable manner, "Well, Legget, you don't know how good one University is until you've seen another; I think you should take it. Go to Toronto and see what the place is like – but be sure to come back." So I accepted, although when I saw Dean Clarke's disappointment, I felt badly about my decision.

I had naturally discussed the matter with Lindsay Malcolm; he listened attentively but said little. When finally, I told him my decision, he surprised me by saying, "Now let me tell you something." He had been offered the position of head of the Department of Civil Engineering at Cornell University at the same time as I had received my offer from Toronto. Since by this time he knew me, he decided to postpone his decision until I had made mine since, as he said, he knew that if I knew he were leaving, I would not leave at the same time because of all that had gone into that laboratory.[14] I relate this incident to indicate a measure of the man who was such a good friend but, as I look back, I realise now that it was another of those turning points in my life when the fates were indeed kind to me (and to my interest in Geotechnique).

While all this was going on, I was faced with my first consulting job, a critical redesign of a cofferdam which had failed, killing four men, at Port Stanley, *[Ontario]*.[15] Late one evening, one of the very fine early contractors of eastern Canada, William Bermingham[16] (a man of whom it was said that you never needed a written contract with him; his word was his bond) called on me and most earnestly entreated me to help him; this was the first fatal accident he had ever had in his life and he was determined to see that the job was finished with no more trouble. Only because of my respect for him did I accept. I visited the site; prepared a design (in steel sheet piling); had this checked; and the job went ahead again – but I was not there when they drove the piling, being busy with my teaching duties. We got an alarming message that the cofferdam had failed again. I went up with Bill Bermingham (the son); a traumatic journey which I can still remember and we were soon on the job. It was not a failure of the cofferdam but distortion of

some piles. The Superintendent, even though instructed what he had to do, thought that he knew best and did not follow the specific instructions written large on my cofferdam plan.

It was Larssen piling in use; the interlocks were tight in a way the Superintendent had never seen before; this had caused the trouble. It was soon corrected. The *[Superintendent]* learned a lesson; so did I, that no civil engineer should ever accept responsibility for a design unless he is on the job, or represented, to see it built...a lesson still to be learned by so many.

We moved up to Toronto in the late summer of 1938 and began what was to be a period of nine wonderful years, despite all the stress of war. C.R. *[Young]* was another of the great men with whom I have worked and who must have influenced my own progress. He was a wonderful teacher, a kindly man, highly respected in the profession.[17]

In keeping with his kindness, he told me when I arrived (in a round-about sort of way) that soil mechanics was already being taught in the Department by a long-time member of staff who gave it in his highway engineering course.[18] But, he added, he wanted me to develop a proper soil mechanics laboratory and with his strong support, I did so in a basement room of the (old) Electrical Building, then used also by the Civil Department.[19] Using the drawings of a direct shear box that I had brought from Queen's (with Sandy *[Macphail's]* permission), Bill Kubinga, the excellent man in charge of the machine shop, made a shear box and stand and these were ready to be used early in 1939.

C.R. had very firm views on the place that consulting work should occupy in his department. He encouraged his staff to do this provided that (1) it was in their own field of study; (2) it did not in any way compete with regular consultants; (3) it did not interfere in the slightest with University duties; and (4) when possible, it would result in a research publication.

He was meticulous in following these guidelines himself. From the number of visitors to his office, his services must have been much in demand but he accepted very few assignments. He kindly passed on to me one or two smaller inquiries, of no great significance here even though they usually involved soils. One request that he did not turn down, however, was from Dr. H.G. Acres[20] for assistance with the Shand Dam.

This dam was to be built in the headwaters of the Grand River, of southwestern Ontario,[21] by the Grand River Conservation Commission. It was the first structure to be built for conserving the waters and soil of southwestern Ontario, now a splendid movement covering all of the area through River Conservation Authorities.[22] Prime objective at the Shand Dam was to control flooding on the Grand River i.e., to undo what men had done to the Grand River valley by clearing it during the last century.

It was on 4 March 1939 that Andy McQueen, one of Dr. Acres' associates, called on C.R. to discuss the project for which they were to be the consultants. They had the idea that, apart from the necessary concrete spillway, the dam might be built of soil. C.R. discussed the matter with me after Andy's visit. I said that I thought I would have the shear box in action within a

week or two, being already equipped for simpler tests such as for soil compaction and permeability. Accordingly, McQueen and Bob McMordie came *[to Toronto from Niagara Falls]* to spend most of the day with me discussing the whole idea, the design of earth dams, the necessary soil testing etc., this being on 31 March. It was agreed that soil test pits should be put down around the dam as a first step. These showed glacial till over a wide area, examined by a group of us on 5 May; at about that time, the bold decision was taken by Acres to proceed with an earth dam.

The Shand Dam was, I think, a pioneer structure for North America. The two main embankments are built entirely of glacial till, with no core wall but with suitable drainage features. Fortunately a good contractor won the job and followed instructions (from Acres) very well, even though compacting till in layers at proper moisture content had not been seen before in eastern Canada. The job was finished in the summer of 1939[23] and the dam has performed well since. (I paid a brief visit to it again in 1980 and was delighted at how well it looked). Fortunately, this pioneer work in soil mechanics was well-written up by the two men mainly responsible in a "key" paper published in the *Engineering Journal,* then still the main Canadian outlet for such professional papers.[B]

All the soil testing was done in my lab at the University of Toronto, so it was a busy place so early in its history, with several student assistants helping me. I got more and more baffled by the variations in the properties of the till; if I had then known more about the geology of tills, the paper I wrote summarising our work (another very "amateurish" effort) would have been very different.[C] But before there was any opportunity to follow up some of the many questions raised by all the work on the Shand samples, the war loomed up as a possibility and, finally in the early Fall of 1939, as an actuality.[24]

There is one footnote to be added about the Shand Dam. Right from the start, the Acres office appreciated the importance of the site geology. They approached the Geological Survey of Canada and the officer in charge of their work in SW Ontario became a member of the Shand team in an informal way – Dr. John F. Caley.[25] He became a close friend of mine, the start of a happy liaison with the Survey.

[B] McQueen, A.W.F. and R.C. McMordie .1940). "Soil Mechanics at the Shand Dam," *Engineering Journal*, Vol 23, pp 161-*[??]*.

[C] Legget, R.F. 1942. "An Engineering Study of Glacial Drift for an Earth Dam, near Fergus, Ontario," *Economic Geology*, Vol 37, pp 531-*[??]*; reprinted in 1943 in the *Engineering Journal*, Vol 26, pp 502-508.

Annotations Chapter 10: DEVELOPMENTS IN EASTERN CANADA (1936-1939)

[1] Legget is referring to Professor I.F. Morrison from the University of Alberta. See Chapters 1 and 8 and their annotations.

[2] Legget is referring to Robert Hardy's contribution to the early 1980's CGS Geotechnical Heritage Book Project (see VanDine and Heinz 2020).

[3] In 1940, under "the Chief's" (Richard Chadwick's) leadership, the Foundation Company of Canada formed a Soils Engineering Department to carry out site investigations and to support the company's diverse land and marine construction of projects across Canada. This could be the first private soil engineering group in Canada.

[4] Used in this context, "imprimatur" is a form of approval or endorsement.

[5] Edward Fetherstonhaugh, an electrical engineer, was the first Dean of Engineering of the University of Manitoba (1921 to 1949) (University of Manitoba website).

[6] Founded in 1907, the Nova Scotia Technical College was renamed the Technical University of Nova Scotia in 1980. In 1997, it merged with Dalhousie University. Frederick Sexton was the founding principal (a position renamed president) from 1907 to 1947 (Wikipedia).

[7] John ("Blinky") Stephens was Dean of Engineering of the University of New Brunswick from 1920 to 1945. It is not known why Legget considered him famous.

[8] Although not mentioned in his memoir, in January 1936, Legget applied for a teaching position advertised by the Civil Engineering Department at the University of Liverpool, the John William Hughes Chair of Civil Engineering (LAC 1-7). He was unsuccessful.

[9] Legget was hired as a lecturer to assist Sandy Macphail teach "General Engineering 1". This was a 2nd-year course for all engineering students; two lecture hours per week, both terms (Queen's University calendar).

[10] Robert Charles Wallace (1881-1955) was a Scottish-Canadian geologist. He was President of the University of Alberta from 1928 to 1936 and Principal of Queen's University from 1936 to 1951. He was the first scientist to become Principal of Queen's (Wikipedia).

[11] William McNeill (1876-1959) was a Professor of English who became Registrar and Treasurer of Queen's University in 1920. He is credited with helping Queen's survive the Depression without drastic cutbacks (Queen's University Encyclopedia website).

[12] Professors Alexander (Sandy) Macphail, William Wilgar, Douglas Ellis and Lindsay Malcolm and lecturer R.A. Low (Queen's University calendar). Why Legget considered the Department of Civil Engineering unique and what the historical explanation was are unknown.

[13] Alexander (Sandy) Macphail (1870-1949) became a professor of Civil Engineering at Queen's in 1904 and was department head until 1939. He held the unique position of Professor of General Engineering. During the First World War he was a major in the 5th Field Company Canadian Engineers militia unit comprised mainly of Queen's engineering students. For his work during the war he was awarded the CMG (Companion of the Order of St. Michael and St. George) and the DSO (Distinguished Service Order) for his distinguished service in action (Queen's University Encyclopedia website).

[14] A year after Legget left Queen's, Malcolm left Queen's and joined the faculty at Cornell University.

[15] Port Stanley is a small community on the north shore of Lake Erie, south of London, ON. It is approximately 400 km west of Kingston.

[16] Bermingham Construction Limited was founded in 1897 by William Bermingham and is still a thriving privately owned family business today. Based in Hamilton, ON, its construction arm includes pile foundations, excavations and shoring and marine projects. It also sells, rents and services foundation construction equipment (Bermingham website).

[17] C.R. Young is introduced in Chapter 8 and its annotations.

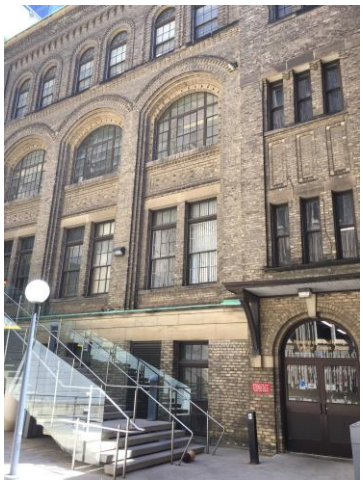
Clarence Richard Young in 1947 (photo source White 2000)

[18] Here Legget's memory differs somewhat from the University of Toronto 1938-1939 Applied Science and Engineering calendar. In that calendar, "Soil Mechanics" was a 4th-year course (one lecture hour per week, first term) taught by W.L. Sagar. The course was introduced in the 1936-1937 session, immediately after the International Conference held in June 1936, and was taught that year and the next year by Young, who had attended the 1936 conference.

During Legget's first two years at the University of Toronto, he co-taught with Sagar "Foundations, Retaining Walls and Dams." It was a 4th-year course (one lecture hour per week, both terms). This, or a similar course, had been taught since at least the late 1920s.

In the same two years, Legget also taught "Graphical Methods," a 3rd-year course (one lecture hour per week, both terms), and co-taught "Structural Design", a 5th-year course (one lecture hour and three laboratory hours per week, both terms), both structural engineering courses (University of Toronto calendars).

[19] The Electrical Building at the University of Toronto was opened in 1920 to help alleviate the large enrollment of engineering students after the First World War. It was renamed the Roseburgh Building in 1936 but Legget refers to it by its original name. Today its exterior is all but swallowed up by the Donnelly Centre for Cellular and Biomolecular Research (University of Toronto website).



Basement entrance of the Electrical Building (Roseburgh Building). Legget's soil mechanics laboratory was in this basement. The staircase to the left leads to the Donnelly Centre opened in 2005. (photo Doug VanDine 2019)

[20] Henry Girdlestone Acres (1880-1945) was a 1903 civil engineering graduate from the University of Toronto. He pioneered hydroelectric power development in Canada. He was one of the first employees of the Hydro-Electric Power Commission of Ontario, which became Ontario Hydro. He was chief hydraulic engineer for the Niagara Falls Generating Station at Queenston/Chippewa and started the consulting firm H.G. Acres and Company in 1924 (*Canadian Consulting Engineer* website).

In the 1970s, H.G. Acres and Company changed its name to Acres International and in 2004 was purchased by, and now works as a subsidiary of, Hatch Ltd.

[21] The Shand Dam is on the Grand River near Fergus, ON, approximately 35 km north of Kitchener-Waterloo. It was the first dam in Canada to be built for multiple purposes: flood control, water supply and water quality (Grand River Conservation Authority website).

Fig 15.1 in Legget's and Paul Karrow's *Handbook for Geology in Civil Engineering,* published in 1983 by McGraw-Hill. The caption of this photo by Legget reads "The Shand Dam on the Grand River, Ontario, a dam built of glacial till with no core wall". Notice that Legget included a train in the photo.

[22] Today there are 36 conservation authorities in Ontario, 31 in southern Ontario and five in northern Ontario. They "are community-based watershed management agencies, whose mandate is to undertake watershed-based programs to protect people and property from flooding and other natural hazards, and to conserve natural resources for economic, social and environmental benefits and are legislated under the 1946 Conservation Authorities Act" (Conservation Ontario website).

[23] Legget's memoir states "The job was finished in 1939". His portion of the project was completed in 1939; however, dam construction was completed in 1942 (Grand River Conservation Authority website).

[24] Canada entered the Second World War on September 10, 1939.

[25] John Fletcher Caley (1903-1971) was a University of Alberta (BSc) and University of Toronto (MSc and PhD) trained geologist. He joined the Geological Survey of Canada in Ottawa in 1935 and during his career, among other achievements, he either mapped, or directed the mapping of, most of bedrock geology of southern Ontario. (Geological Society of America website) Caley investigated the bedrock geology for the Shand Dam and contributed the geology sections to Legget's 1942 paper on the Shand Dam in *Economic Geology*.

[Chapter 11:] THE WAR YEARS (1939-1945)

The first impact of the war on work at the University of Toronto, and specifically on the Department of Civil Engineering was a visit I had, in the Fall of 1939, from a courteous gentleman named Roewade who explained that he was a Danish-Canadian, a brewmaster with one of the big breweries! I wondered what this had got to do with me, but he went on to explain that a nephew of his, a brilliant young Danish engineer, had won a Danish State scholarship for graduate study at the University of London (England) after *[having spent]* some years with Christiani and Nielsen, the big contractors.[1]

[The nephew] had given up his job but when he got to London, *[the university]* had just decided to cancel all graduate study because of the incidence of war. They recommended that he should apply to *[the University of]* Toronto since, in some way I never did fathom, they knew that I was there and had started work in soil mechanics, which the young man was anxious to study. Would I take him as a graduate student if he came to Canada? To that, said C.R. Young, there is only one answer and so, towards the end of the year, Per Hall arrived to be my first graduate student.

It was a pleasure working with Per Hall, his practical experience very quickly putting us "on the same wave length," as also his wife who came to Canada with him, herself a civil engineer. After a few weeks of preliminary discussions and study, we both found ourselves attracted by the significance of Professor I.F. Morrison's paper on pile fundamentals[A] and so, with C.R.'s agreement, we decided on the correlation of soil properties with the supporting power of bearing piles as the subject of Per Hall's thesis.

Not many days after deciding this, he appeared in my office one morning with the tragic news that Denmark had been over-run by German troops,[2] cutting him off from his family, his Government, *[and]* his funds. All else was put aside while we helped him to try to join the RCAF, but his Danish citizenship stood in the way of this, naturally for that time.[3] Disappointed, he accepted the inevitable and joined the Aluminum Company of Canada,[4] his knowledge of Danish enabling him to make a significant contribution to the war effort of this company, especially in the Virgin Islands;[5] later he transferred to the Foundation Company and eventually set up his own office.[6] Now I wonder if this was the start of graduate work in Geotechnique in Canada.[7]

1940 was the time of the "phony war"[8] but by this time we, at the University, knew that the Government had decided that no University staff (at least in engineering) would be permitted to join the armed forces.[9] This was, for me, a keen disappointment but the decision had to be accepted and I can now see (although not at the time!)that the decision was a wise

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[A] Morrison, I.F. 1939. "The Fundamentals of Pile Foundations," *Engineering Journal*, Vol 22, pp 431-434.

one and essential for the national war effort. Our energies had, therefore, to be turned in other directions, once essential University duties were done. The latter grew in intensity with classes to be taught; Statics numbering well over 300 students etc. and so all University research came quickly to a standstill.[10]

Again, I was most fortunate in the "outside" demands made upon me. The first, early in the summer of 1940, was to assist a great friend (*[D. Hutchinson,]* the *[Construction]* Superintendent of the Upper Notch job of 1929-1930) who had been charged by the Hudson's Bay Company with getting their Mackenzie River Transport[11] organisation shipshape; it had just grown "like Topsy" and really had no organisation to speak of! Behind this was, of course, the Eldorado mine on Great Bear Lake and the need for getting their ore out from the North; at the time this was not known or even suspected.[12]

It is a complicated story, of no special importance here but I spent the whole summer at Waterways, Alberta, the headquarters of the Mackenzie River Transport, then a tiny settlement of 150 people![13] In the course of my travels, I visited Fort Smith in the Northwest Territories, and went even further North being thus introduced to Permafrost, although the name had not then been coined.[14] This new aspect of soils fascinated me and I found out all I could about what was then known. This resulted in another very amateurish paper *[of mine]*, of significance (perhaps) only because of the date when it was published.[B] Little did I then think that I would come to know so much more of the North, and Permafrost.

On my journey out from the North, (I think) I called on Professor Morrison in his (then) tiny office on the campus of the University of Alberta and gained more insight into his sound thinking.[15] I do not recall meeting anyone else during that visit; maybe Bob Hardy can correct me on this.[16] Then I came east by way of Purdue University where there was held the second major soil mechanics conference on this continent.[17]

My main memories of the meeting are personal, apart from the diatribe of Arthur Casagrande against all forms of shear test except the triaxial! In his usual enthusiastic way he "went overboard" about this new form of test. On the urging of other friends, notably Bill Housel,[18] I was put up to answer *[Casagrande]* with amusing results, far too detailed for this record. My main memento from the meeting is a snapshot of D.P. Krynine and G.P. Tschebotarioff standing together, probably the only such record in existence since (although I did not know it when I asked them to stand for me) they were bitter enemies and never spoke to one another! (I have not looked again at the Conference Proceedings but will do so when time permits; this may permit me to add a bit more about this excellent meeting, the memories of which were soon clouded over by the war.)[19]

[B] Legget R.F. 1941. "Construction North of 54ºN," *Engineering Journal*, Vol 24, pp 346-348 (paper given to the London Branch of EIC in 1940).

Back, then, to Toronto to a very busy winter with University work[20] while the tempo of the war got steadily worse; no one could see what was going to happen. It was not too great a surprise, therefore, when Andy McQueen (of the H.G. Acres office) called on me in February 1941, to tell me privately that there was a possibility of the long-planned and great Shipshaw power project going ahead for the Aluminum Company of Canada; the metal already one of the critical materials in the war effort. He wanted to know if I would be willing to help them with the necessary foundation studies if and when a start was made. Again, there was only one answer to be made.

We kept in touch in the weeks following. This was the year when Dean Mitchell[21] persuaded the Faculty of Applied Science at UofT to grant all students their degrees, or year-end results, on the basis of their work during the term; i.e. without writing any examinations, and so the term's work ended early. (The action was a profound mistake and graduates were among the first to realise this when they faced up to urgent problems in their first jobs; three of them told me this, individually, during the summer when we were all living together at Arvida *[while working on the Shipshaw job]).* As a result of this, we were all free of University duties earlier than usual. I went over to Niagara Falls for a briefing meeting *[with H.G. Acres and Company]* on 5 May (1941) and left for the Lake St. John country[22] on 8 May staying up there on the Shipshaw job until 12 September when I had to return to Toronto for the winter's work at UofT.

It is difficult to write briefly about this remarkable job—one of Canada's greatest civilian wartime projects—but I will be as brief as possible. When the initial development of the Saguenay River was carried out (by the Duke Power Company, I think[23]), a dam and power house were built at Chute-à-Caron on the main river to provide power for the initial aluminum smelter at Arvida. It was then intended, that when more power was needed, the Chute-à-Caron Dam would serve to divert the whole flow of the Saguenay into a depression in the local Precambrian rock to the north. There, by means of a number of "saddle dams,"[24] a vast reservoir or headpond could be created from which the whole flow of the river could be led to a power house with its tailrace level almost at sea level, thus gaining the extra head in the rapids below Chute-à-Caron in addition to the head there. The result was a power house developing 1,200,000 HP,[25] all the works for which could be constructed "in the dry" while the river flow continued to go through the Chute-à-Caron plant and its associated spillway. This was the Shipshaw project, in brief.[26]

Once the decision to proceed had been made, the whole job was completed in eighteen months, despite one of the most severe winters ever experienced in the area—one of the greatest construction feats ever carried out in Canada and yet still virtually unknown.[27] It was

described in a series of papers by one of the Aluminum Company's executives, Dr. Acres and Bert Younghusband of the Foundation Company, the main contractors.[C] [28]

In May, the decision to proceed had not yet been made but, such was the critical urgency of all wartime efforts related to aluminum, it was decided to get ready with plans; the foundation studies had therefore to proceed at top speed. Two (or three?) drill rigs were on the site when I got up there, being supervised by Don Miller, a mining engineer who had previously worked for Acres. We were soon "in harness," advised in a wonderful way by Dr. E.C. Harder, chief geologist of Aluminium Laboratories[29] who visited us regularly.

Five retaining dams had to be built across soil-filled valleys; exploration, therefore, involved soil sampling and diamond drilling at all five dam sites as well as test pit exploration, and diamond drilling and a test shaft in the bedrock at the power house and penstock locations. It is, today, difficult to convey the pressure under which we worked, pressure that must excuse the inadequacies and limitations of the geotechnical work I was able to "squeeze in." We worked all day and all evening six days a week, relaxation being on Sunday evenings, such was the challenge ahead of us. One slight break was a talk I find that I gave on Soils and the Engineer, to the local (Saguenay) Branch of the EIC on 24 July 1941![30]

Two aspects of our work are of significance for this record. Since the soils we encountered were not going to be used, but just removed from above the bedrock *[that was to be]* used for all foundation beds, there was no need for anything other than identification tests.

With the help of the Chief Chemist of Aluminium Laboratories (who had a large research lab at Arvida), I was provided with a tiny lab and there assembled the necessary equipment (borrowed, I think, from *[the University of]* Toronto) for simple soil tests. Much of the excavation was to be in gray clay, the properties of which soon had me baffled. All my tests showed that the natural moisture content was higher than the liquid limit.[31] I decided that I must be a poor technician. There was nobody knowledgeable whom I could consult. Mr. Rimmer (Chief Chemist) was interested and helpful, offering to do the tests himself as a check. He got exactly the same results. I could see the effect of this; i.e. that if the soil was disturbed, it would flow, without knowing why. So I told the contractor, after work had started, and was politely laughed at...they wanted none of that academic nonsense on a priority job like this. I confirmed my advice in writing since they were disposing of *[the excavated material]* in locomotive-hauled dump cars on temporary track.

Late one Friday night, one of the dump trains, locomotive and cars, went over the edge as the large pile of clay started to flow down to the Shipshaw River. I was hauled out of bed around midnight and very politely asked what it was I had said about this...soil! After that, my relations with the men in charge of excavation was all that could be wished for; and I had had my introduction to Leda clay.[32]

[C] DuBose, McNeely. 1944. "The Engineering History of Shipshaw," *Engineering Journal*, Vol 27, pp 194-220, with companion papers on "Design" by H.G. Acres, and "Construction" by V.G. Younghusband.

In our test borings at Dam site No 5, we spotted some organic matter about half way down to bedrock, with clay above and below it. This was very puzzling since the layer was about twelve inches thick and even from our sampling tools we got specimens of identifiable wood (cedar being one I can recall). So again I warned the contractors and again was politely ribbed for my crazy ideas. But when the large excavator at the site got down to the level I had indicated, there was a bed of organic matter stretching right across the site. It included stumps of trees, some with beaver marks on them, others still with the smell of burning on them. Excavation was difficult but I watched it carefully and got some good samples to take back to Toronto. There I consulted a new friend (who had done graduate work at *[the University of]* Glasgow under an old friend of mine) who was in the Department of Botany with special interest in the very erudite field of palaeobotany.[33] [*My new friend]* was fascinated by the samples; we decided that when the war was over we would publish joint papers on this strange occurrence. And this was my introduction to Dr. N.W. Radforth,[34] and the real start of muskeg research in Canada.

For convenience, I have given these detailed notes about the significant parts of my Shipshaw experience. Let me now quickly summarize the main events of that summer. We pressed on with our work and managed to keep ahead of the design team, *[H.G. Acres and Company in]* Niagara Falls, having regular visits from Dr. Acres and his three senior colleagues. They kept us advised of policy developments and so we heard, about mid-summer, that the job was to go ahead, with the highest possible priority, an overall contract having been negotiated with the Foundation Company of Canada Ltd. Bert Younghusband was to be in charge for them, a fine man with whom it was a pleasure to work. Speed was everything, expense secondary.

To one like myself, trained in good economic construction, this was difficult (at first) to accept but the imperative of war soon corrected that. Sometime later, I found that Dr. Acres had gone to Dr. Young at UofT, to ask him to grant me leave of absence so that I could be the chief Resident Engineer for him on the job, but C.R. refused, saying that I was needed at the University. I was a bit "miffed" when I heard this but again, as happened so often with me, I came to see that it was the right decision. I went back to the job in the summers of 1942 and 1943 to see the final stages of construction, and the splendid finished job. Even today, I look at it in unbelief as I recall the hectic days of construction.[35]

As the war neared its close, Bill Radforth and I took out our Shipshaw notes and prepared two papers for publication. In those days, the only possible outlet in Canada for *[geological]* papers was through the Royal Society of Canada.[36] One had to have a paper sponsored by a Fellow at an annual meeting; if acceptable, it might then be published in the Society's *Transactions*. (This will read strangely to younger workers of today, but this <u>was</u> the

situation!) And so our two papers were presented in Kingston at the 1945 annual meeting of the Royal Society, and later published in the *Transactions* of the Society.[D] [E]

Since I was so uncertain of my laboratory results, I decided not to include them in the paper; I can now see, of course, that this was a mistake. Fortunately, I had the opportunity of correcting this omission because of another error in our papers. None of those with whom we consulted could suggest why we found the bed of organic matter "sandwiched" between two strata of Leda clay, the idea of a landslide being apparently out of the question because of the *[relatively flat]* surrounding topography. More than a quarter of a century later, Pierre LaSalle (of the Quebec Department of Natural Resources) found evidence of an immense landslide in this region. I was able to tell him the exact location of the bed of organic matter, which he then uncovered in a test pit and was able to study in detail. We then combined to prepare a paper correcting the mistakes of the earlier one, and including the results of his more recent work.[F] These three papers form, therefore, a somewhat unusual early contribution to Geotechnique in Canada.

Throughout the war years I was asked to undertake a number of smaller consultancies, consistent with the prior claims of university work. Some requests came through C.R. Young, others directly to me. All involved soil problems in some way but there is no point in attempting to list them since they were all relatively simple problems. I did my best to keep good notes and, after the experience of *[presenting]* the Shipshaw paper to the Royal Society and the welcome that it got in the (then) Geological Section, I wrote up two short papers after the war about two of these jobs since they seemed to be useful geological contributions.[G] [H] I list them here since the *Transactions of the Royal Society of Canada* would not be thought of as containing any early geotechnical contributions!

As the war neared its end, Mr. Chadwick, of the Foundation Company, wanted Canada to be ready in this new field *[of soil mechanics]* and so invited Dr. Terzaghi to come and spend a day in Montreal, as his guest, and to present a paper to the Montreal Branch of the Engineering Institute *[of Canada]*. When his invitation was accepted and the day fixed, "the Chief" got in touch with me and asked me to come to Montreal as his guest also, in order to keep company with Dr. Terzaghi throughout the day. This was on 12 October 1944.

[D] Legget, R.F. 1945. "Pleistocene Deposits in the Shipshaw Area, Quebec," *Transactions of the Royal Society of Canada*, Series 3, Section 4, Vol 39, pp 27-39.

[E] Radforth, N.W. 1945. "Report on the Spore and Pollen Constituents of Peat Bed in the Shipshaw Area, Quebec," *Transactions of the Royal Society of Canada*, Series 3, Section 4, Vol 39, pp 131-142.

[F] Legget, R.F. and LaSalle P. 1978. "Soil Studies at Shipshaw, Quebec: 1941 and 1969," *Canadian Geotechnical Journal*, Vol 15, pp 556-564.

[G] Legget, R.F. 1946. "A Note on Pleistocene Deposits of the Sarnia District," *Transactions of the Royal Society of Canada*, Series 3, Section 4, Vol 40, pp 33-40.

[H] Legget, R.F. 1948. "A Note on Pleistocene Deposits near Three Rivers [Trois Rivières], Quebec," *Transactions of the Royal Society of Canada*, Series 3, Section 4, Vol 42, pp 55-60.

It started with lunch at the St. James' Club;[37] there was a fine dinner at the Windsor Hotel[38] (to which the Chief invited Mrs. Legget and one or two other ladies)—preceding the EIC meeting. During the long afternoon, I had Dr. Terzaghi to myself. We walked up Mount Royal, by which he was delighted, and spent some time at the famous lookout, just talking. It was then that, in effect, he gave me the challenge of my life, as related in my Terzaghi Lecture to ASCE.[I 39] Naturally, it was a day never to be forgotten; much of what I was able to do in this field after that was due to the inspiration that being with him then gave me.

There was another by-product of the Shipshaw job. Dr. Acres asked me to go and have a look at the La Tuque development of the (then) Shawinigan Power Company, on the St. Maurice River,[40] since he had heard that they had an unusual groundwater situation there and he wanted to know about it, just in case we ran into anything similar at Shipshaw. There was indeed an unusual groundwater situation at La Tuque, on which I duly reported to Dr. Acres; we did not have any comparable situation at Shipshaw, but the visit opened my eyes to the significance of groundwater in all geotechnical site studies.

This was reinforced by a minor but comparable problem on the Forestville project,[41] for which I was consultant to the Anglo-Canadian Pulp and Paper Company. Fortunately, I was able to keep good notes so that many years later, after finding again and again how groundwater was neglected, I wrote them up into a paper for *[the American Society of Civil Engineers]*.[J] This was, I think, the only geotechnical paper I had published which elicited no official discussion at all—confirming just what I thought was the general neglect of groundwater. I did get one or two personal letters commending the paper, one man saying he wished that he had written it, but it really did not "make a ripple on the waters" and groundwater continues to be (in my opinion) the Cinderella of Geotechnique.

Two major wartime jobs finally call for mention; both of them went on after the war, the second for many years, but they started under the pressure of the wartime effort and so call for mention here.

The first was the construction of the Polymer synthetic rubber plant at Sarnia,[42] another superb Canadian wartime project which was never written up (as it should have been) since all of those closely connected with it went on to other high-pressure jobs. When the Japanese over-ran the Far East, supplies of rubber were cut off from the allied forces. Manufacture of artificial rubber immediately took on the highest possible priority. The United States planned to build all six emergency artificial plants themselves until Rt. Hon. C.D. Howe[43] (as he once confirmed to me) made a dramatic move in Washington. This won for Canada the very grudging consent of the US wartime production chief for the privilege of

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[I] Legget, R.F. 1979. "Geology and Geotechnical Engineering," *Proceedings American Society of Civil Engineers*, Vol 105, GT3, pp 339-391.

[J] Legget R.F. 1962. "Experiences with Groundwater on Construction," *Proceedings American Society of Civil Engineers*, Vol 88, SM2 pp 1-17.

building the sixth plant *[in Canada]* (the only one to make rubber by the two known methods, instead of by just one method as all the five US plants). Canada started last, therefore.

Canadians generally should know that the Polymer plant was constructed so well and so quickly (operating within eleven months) that the first carload of Styrene[44] made there, left (in a great hurry) to help the first US plant start up its production. Behind that achievement there naturally stands a superb job of organisation and cooperative engineering and construction.

To direct this great construction enterprise, Mr. Howe borrowed the services of Mr. R.L. Hearn (now Dr.), then Chief Engineer of Ontario Hydro.[45] At the peak of construction, Mr. Hearn had working on the one-mile square site at Sarnia about thirty contractors and something like a dozen consulting engineers. All the plant designs came from the US, but the site preparation and all services including roads, a large steam power house, pumping plant etc., were designed by the Acres office.

Work went on steadily six days a week, twenty four hours a day; Sundays were to be taken off by everyone, except the maintenance gangs who, in this way, kept all construction plant at top efficiency. To achieve this result, Mr. Hearn had six special assistants, all engineers, one mechanical, one electrical, one chemical, one petroleum, and one civil, the sixth being a sort of "engineering office-boy" to do jobs that fell outside of the fields of the other five. It was my privilege to occupy this lowly position, working most weekends and nights when necessary, while still carrying on with University work. And early Geotechnique was there!

The civil assistant to Mr. Hearn was Jim Knight, staff engineer with the company that then supplied calcium chloride; Jim had made a real study of soil stabilisation using CaCl.[46] Mr. Hearn's vision and standing as an engineer is shown by the fact that, after *[a]* briefing by Jim, he laid down as a firm rule that, despite the intense urgency of the job, nothing should be done on the site until <u>all</u> construction roads had been laid out, and constructed, using stabilised soil, under Jim Knight's direction. Well do I recall the criticism to which *[Mr. Hearn]* was subjected by impatient contractors but he stuck to his guns, and all construction roads <u>were</u> finished before access to the site was granted; as the result, not five minutes was ever lost on the job because of road failures despite the heavy construction traffic.

(I am quite sure, in memory, that Jim Knight wrote a little paper on this road work and I think that it was published either in *The Canadian Engineer*, if this had not by that time split up, or in one of its sections called *Roads & Bridges*. Unfortunately, my notes do not contain this reference and, if I still have a copy, it has disappeared into my wondrous filing system, so far unretrieved! But in any bibliography that may be prepared for the start of Geotechnique in Canada, this paper should have an honoured place.)[47]

The geology of the site (part of the old Indian reservation at Sarnia[48]) was straight forward so that all foundations, I think, were on the local clay-till. I recall doing soil shear testing of this for Acres but they were responsible for all foundation designs, including that of the power house, the largest steam plant in Canada.

After much discussion and partly because of necessary speed, it was founded on a "floating foundation" which must have been one of the first, if not the first large foundation structure of this type in Canada. There was a paper written on this part of the job by an engineer named Hvilivitsky, a fine member of the Acres team who died young, I think.[K] The power house is still there, although now oil (or gas?) fired instead of with coal, as originally built; it might be a job worth following up if someone is looking for a graduate thesis subject!

The coal supply, of 600,000 tons per year, raised one of the biggest policy questions in design, solved (to cut a long story short) by making it the first steam plant on the Great Lakes to have its entire coal supply handled by earth moving equipment without the usual travelling gantry etc., a development which I wrote up for *[the American Society of Mechanical Engineers]*,[49] but which is hardly relevant here. What is a part of the geotechnical *[story]* was the plugging of the large coal bunkers in the power house.

After a man's life was tragically lost through this (and not following instructions), I was asked to look into the problem. I set up a small experimental model plant in the UofT soil mechanics lab, and eventually found the cause (moisture content!) and so was able to suggest a solution.[L] In this work I was helped by a graduate assistant whose name was Donald H. Macdonald[50]—the beginning of a lasting and valued friendship!

"Polymer," therefore, has an important place in this story, as also does Steep Rock. This was the name given to a high quality iron ore deposit found, by geophysical methods, beneath the bed of Steep Rock Lake, near Atikokan in western Ontario.[51]

In 1943, with supplies of iron ore in a critical state, the decision was made, jointly by the Canadian and US governments, to develop this valuable deposit even though it meant draining the Lake. Diversion works were necessary (a tunnel and big cut) before both ends of the Lake could be sealed off; these were undertaken in 1943 (Acres being the consulting engineers), so that the very large floating pumping plant started operation in the late winter of 1944, while the surface of the Lake was still frozen. Water level had been dropped about 75 feet when the spring thaw started and then things began to happen. I got a frantic telephone call on Good Friday 1944, asking me to get up to the Mine as quickly as I could.

When I got there, I was treated to one of the most remarkable sights I have ever seen in my life. It was a lovely spring day when we got to the south end of the Lake, the ice cover glistening in the bright sunshine, trickles of water all around testifying to the thaw that was then well underway. Due to the drop in water level, the ice-sheet was broken all around the edge of the Lake, exposing the lake-bed sediments. As these thawed, and because of their

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[K] Ings, J.H. and Hvilivitsky J. 1944. "Some Structural Features of the Polymer Corporation Steam Power Plant," *Engineering Journal*, Vol 27, pp 394-399, July 1944.

[L] Legget, R.F. 1947. "Clogging of Bituminous Coal in Bunkers," *Transactions of the American Society of Mechanical Engineers*, Vol 69, pp 525-533.

unstable condition, they slid into the lake—so I saw landslides innumerable, all round the lake as far as the eye could see.

I recall one very large one (200,000 to 300,000 cubic yards) taking place close to us, going out in a few seconds with an awe-inspiring "shwoosh." Quite naturally, there was panic among the mining engineers who, in the general pattern of mining work, had just regarded soil as a nuisance. It took quite a time to persuade them that the slides were a perfectly natural phenomenon and must be allowed to take their course.

I need not go into any detail but an incident with ground water, which I had asked them to control at one critical spot on the edge of the Lake but which they neglected, finally, showed them that this was soil that had to be respected. After that, cooperation was all that could be desired. They followed every suggestion I made, the climax coming when I had to move to Ottawa (in 1947) and they asked me please to continue to use their soil as a field laboratory for any research work I wanted to do—and this we did. Since my connection with Steep Rock lasted, as indicated, until after my move to Ottawa, this was one job that I did manage to "write up."[M]

After the open pit mining operation was in successful operation, the Steep Rock Company leased the northeast part of the deposit to the Caland *[Ore]* Company[52] for whom Dr. R.M. Hardy acted as consultant.

By chance, but unfortunately, Bob Hardy and I never met at Steep Rock but he contributed notably to the discussion of the Institution of Civil Engineers paper just noted, and we naturally had private talks about the complexities of the job.

At a later date, we did author a short joint paper (to the Geological Society of America) on a boulder which was found embedded in the varved clay[53] found beneath Steep Rock Lake. Unfortunately, I cannot not find the reference to this; possibly Bob Hardy will be able to add it to the record.[54] But we were joint authors of a much more significant paper which concluded the volume on *Soils in Canada*, the record of what was probably the first general symposium on Soils in Canada, held at the annual meeting of the Royal Society *[of Canada]* in Kingston in June 1960.[N] *[It was published]* as Special Publication No. 3 by the Royal Society in 1961;[55] a revised edition was published in 1965, and this was reprinted in 1968 and 1971, making it one of the most successful volumes ever to be published by the Society.

This work at Steep Rock was, probably, the first linking of geotechnical work in eastern and western Canada. It may not be amiss to record that I was given to understand, privately, that in both cases,[56] the US partners wanted to bring in US soil consultants (in what may still

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[M] Legget, R.F. 1958. "Soil Engineering at Steep Rock Iron Mines, Ontario, Canada," *Proceedings Institution of Civil Engineers*, Vol 11, p 169-188; discussion in Vol 13, pp 93-117.

[N] Legget, R.F. and Hardy, R.M. 1961. "Engineering Significance of Soils in Canada," in *Soils in Canada*, edited by R.F. Legget, *Special Publication No. 3 of the Royal Society of Canada.* pp 218-229.

be called the usual way), but they were advised that there were Canadians who could serve as needed.

It will readily be appreciated that the transition from wartime work to peacetime activities was a gradual process with much overlapping. Some indication has been given to the imperative of war in the jobs described, Shipshaw perhaps most of all, where completing the job in the shortest possible time was the prime objective, over-riding all else. The biggest change to peacetime work was the removal of this imperative, and a chance to look for the best solution, rather than the quickest. And this did not happen overnight since, until 1946, the threat of war was still in the air, as the record of the Associate Committee *[on Soil and Snow Mechanics]* will shortly demonstrate. This part of the record has been kept for separate treatment, even though, chronologically, it is interspersed with some of the jobs already described. For convenience, therefore, the wartime record will stop here, and the beginning of peacetime geotechnical work, as I saw it, *[will be]* briefly related until I get to the time when others can continue the record.

Annotations Chapter 11: THE WAR YEARS (1939-1945)

[1] The firm Christiani & Nielsen was founded in Copenhagen, Denmark in 1904 by Rudolf Christiani, a Danish civil engineer and Aage Nielsen, a Royal Danish Navy captain. Throughout the 20th century it extended its geographic base to the United Kingdom, South America, Australia, Africa and Asia. Currently (2020) most of its work is in Thailand and Southeast Asia. In 2011, the GP Group, based in Thailand, was the largest shareholder (Wikipedia).

[2] Germany invaded Denmark on April 9, 1940.

[3] The Royal Canadian Air Force would not consider enlisting an individual from a German-occupied country, because of the possibility of him/her being a spy.

[4] The Northern Aluminum Company Limited was founded in 1902 in Shawinigan, QC and changed its name to the Aluminum Company of Canada in 1925. At that time it was a subsidiary of the Aluminum Company of America. Between 1925 and 1932, the company harnessed the hydroelectric power of the Saguenay River by constructing the Chute-à-Caron dam and the associated 224 MW hydroelectric plant. It also built an aluminum smelter, then the largest in the world. To support these facilities, the company constructed the neighbouring town of Arvida, in addition to a major port on the St Lawrence River and associated railway facilities.

The company town of Arvida in 1933 with the aluminum smelter in the background (photo source Rio Tinto Alcan website)

In the early 1950s, Alcan (as the company was renamed in 1945) repeated the process near Kitimat, BC. In 2007, Alcan was bought by Rio Tinto. In 2011 Apollo Global Management and FSI (Fonds stratégique d'investissement) purchased 61% of Rio Tinto.

Arvida is approximately 240 km north of Quebec City. The town was named after the then President of the Aluminum Company of America, Arthur Vining Davis. In 1975, Arvida was amalgamated with the Town of Jonquière and in 2002, Jonquière was amalgamated into a larger city, Saguenay (Wikipedia). Geotechnical professionals may remember Arvida because most of the survivors of the nearby 1971 Saint-Jean-Vianney landslide were resettled there.

[5] Some of the Virgin Islands in the Caribbean were colonized by Denmark in the 1800s. In 1917, the Danish islands were sold to the United States, but Danish continued to be the primary language for many years afterward. The Virgin Islands were one of the main sources of bauxite, the prime ingredient in the production of aluminum, for the Aluminum Company of Canada during the Second World War (Wikipedia).

[6] Legget got to know Per Hall and his wife very well. In an unpublished 1983 note Legget wrote that Per Hall was born around 1913. Legget described that the stress caused by Germany's invasion of

Denmark and Per Hall having to look for work in Canada resulted in his pregnant wife going into premature labour. The birth went well and Legget became the godfather of their daughter, Ingrid (LAC 3-17).

In the 1950s, Per Hall went on to become President of the FENCO, the Foundation Company of Canada's engineering subsidiary, before forming his own consultancy based in Montreal. He specialized, as he had with Christiani & Nielsen in Denmark, in constructing underwater tunnels by floating precast sections into place and then sinking them. One project with which he, FENCO and Christiani & Nielsen were associated was the Deas Island (George Massey) Tunnel under the Fraser River in Vancouver, BC. It was opened by Queen Elizabeth II in 1959 and is still in use today (Wikipedia).

[7] In 1940, Per Hall may have been the first graduate student in soil mechanics in Canada. Up until then, all Canadians who wanted to study soil mechanics at the graduate level typically attended Harvard University and studied with Arthur Casagrande. It is not known if Per Hall completed his graduate work with Legget, or if Legget had any other graduate students while at the University of Toronto.

The University of Alberta is considered to have started the first graduate program in soil mechanics in 1945.

[8] The "phoney war" was the eight-month period at the beginning of the Second World War when there was little military action, the period between Germany's invasion of Poland (September 1939) and its invasion of France, the Netherlands, Belgium and Luxembourg (May 1940) (Wikipedia).

[9] Although university engineering staff may not have been able to serve in the armed forces, at times during the Second World War, some of Legget's department colleagues did take multi-year "leaves of absence" from their university duties for "war service." This left more teaching responsibilities for Legget and the remaining colleagues (University of Toronto calendars).

[10] In each of the 1938-1939 and 1939-1940 sessions, Legget taught two courses and co-taught two courses. In the 1940-1941 session he taught three courses and co-taught one course. In the 1941-1942 session, when some of his colleagues went on war leave, Legget taught eight courses and co-taught three courses (his heaviest session of teaching). In the 1942-1943 and 1943-1944 sessions Legget taught six courses and four courses and co-taught three courses and four courses, respectively. Starting with the 1944-1945 session, Legget's teaching load was slightly reduced (University of Toronto calendars). His teaching at U of T is discussed further in Chapter 13.

[11] Mackenzie River Transport used river boats and barges to supply the Hudson's Bay Company trading posts and settlements throughout the Mackenzie River watershed extending to the Arctic Ocean.

A typical Mackenzie River boat and barge in 1963. This boat, operated by the Northern Transportation Company Limited, was the steel hulled *Radium Gilbert* built in 1946. (photo source NWT Timeline website)

[12] The Eldorado mine on Great Bear Lake started mining gold, silver, radium and uranium in the early 1930s. During the Second World War, uranium was secretly mined and used in the US "Manhattan Project," for the development of atomic bombs. The ore was barged from Great Bear Lake, down the Great Bear River, up the Mackenzie River, across Great Slave Lake, up the Slave River, across Lake Athabasca and up the Athabasca River to Waterways, Alberta (present-day Fort McMurray). After travelling more than 2000 km by water, at Waterways the ore was transferred to the Alberta and Great Waterways Railway (now part of the Canadian National Railways) and railed to its destination in the United States (Wikipedia).

Postcard of Waterways taken in the 1940s by photographer Sutherland
(photo source University of Alberta Libraries, Peel's Prairie Provinces Image PC-005215)

[13] Waterways is now a part of Fort McMurray. What exactly Legget, as a civil engineer, did that summer in Waterways is not known. Based on his summer experience, he wrote an article for the March 1941 issue of *The Beaver* (the Hudson's Bay Company's "Magazine of the North") about barging large machinery to a gold mine in Yellowknife. That issue noted that Legget "was engaged last summer on advisory work for Mackenzie River Transport" (LAC 4-85). Regardless of what he did, this assignment introduced Legget to western and northern Canada.

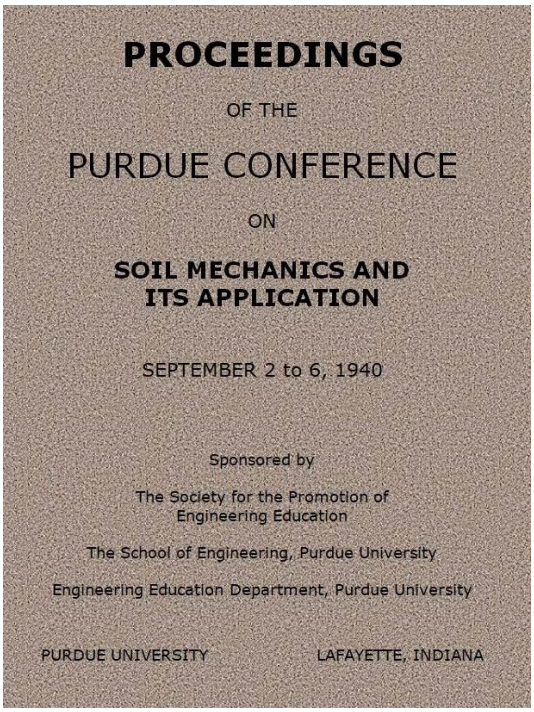
[14] The word "permafrost," a contraction of "perma(nent) + frost," is used to describe permanently frozen ground. The word is attributed to Siemon William Müller, an American geologist, who first used the term in 1943 while researching frozen ground for the US Army during the Second World War (Wikipedia).

[15] Ibrahim Morrison with Legget.

Ibrahim Morrison (left) with Legget, ca 1955 (photo source University of Alberta Archives)

[16] Legget is asking this of Robert (Bob) Hardy, again associated with the CGS Canadian Geotechnical Heritage Project (refer to Chapter 1).

[17] The second soil mechanics conference in North America was the Purdue Conference on "Soil Mechanics and its Applications," September 2 to 6, 1940. The Proceedings were edited by P.C. Rutledge. The conference was sponsored by the (US) Society for the Promotion of Engineering Education and Purdue University, School of Civil Engineering and Department of Engineering Extension, Lafayette, ID. Philip Rutledge, a Professor at Purdue, was interested in soil mechanics as it related to highway road construction. He is introduced in Chapter 8 and its annotations.



[18] Bill Housel is introduced in Chapter 8 and its annotations.

[19] After he submitted his 1983 manuscript, Legget did not provide any further information about this conference.

[20] See an earlier annotation in this chapter with respect to Legget's teaching load during the war.

[21] The year was 1941. Charles Mitchell (1872-1941) was Dean of Applied Science and Engineering at the University of Toronto (1919-1941) and died shortly after leaving this position. He was succeeded by C.R. Young (University of Toronto Skulepedia website).

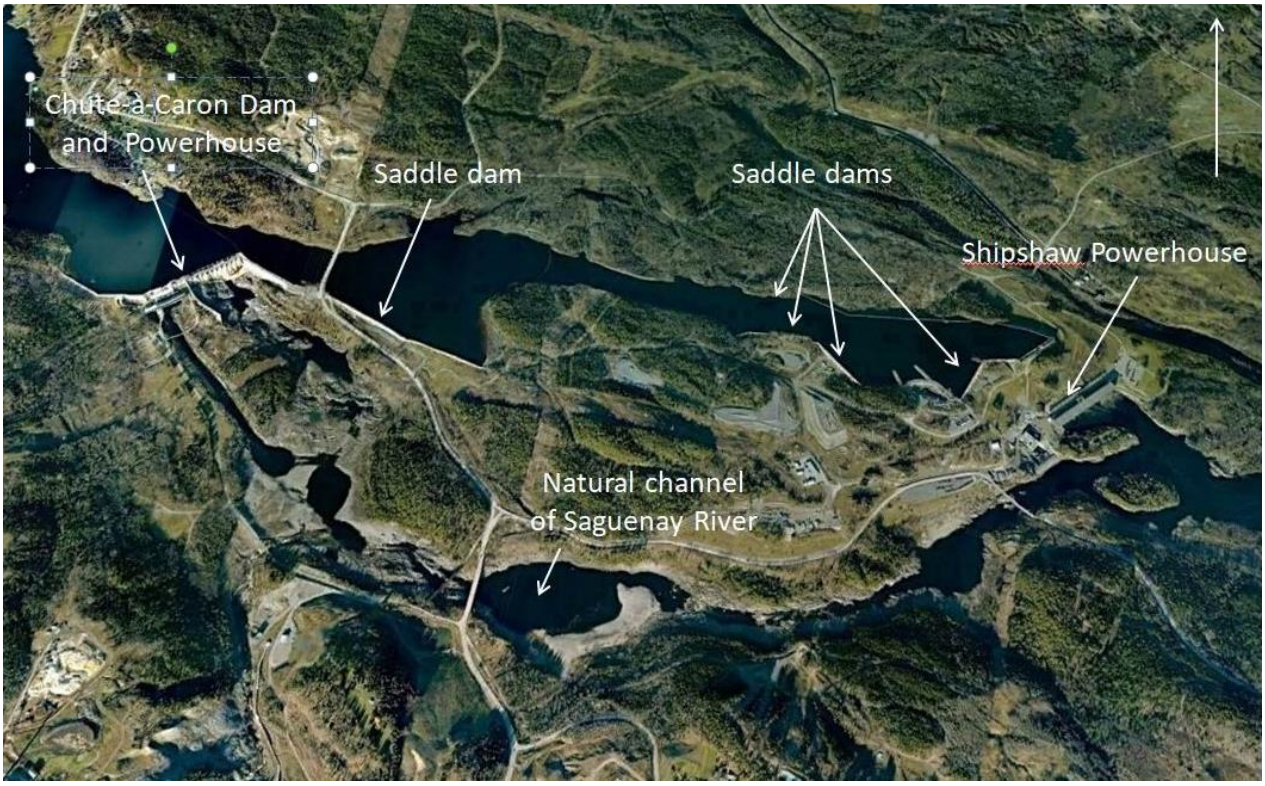
[22] Now referred to as the Lac Saint-Jean area of Quebec, this is the location of what was then known as Arvida and the Shipshaw Hydroelectric Power project. The Shipshaw project was so named because it was located immediately upstream from the confluence of the Saguenay and Shipshaw rivers.

[23] The Aluminum Company of Canada constructed the Chute-à-Caron dam and hydroelectric plant at Arvida in the late 1920s. The Duke Power and the Duke-Price Power companies were both involved in constructing smaller hydroelectric power plants in the area, primarily to service the pulp and paper industry (Cité de l'Aluminium website).

[24] A saddle dam is an auxiliary dam constructed in a low spot, depression or saddle, through which water in a reservoir would otherwise flow (Wikipedia).

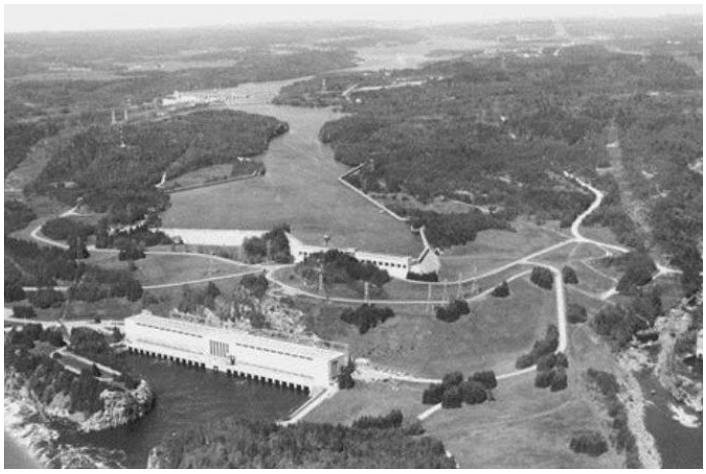
[25] 1,200,000 HP is approximately 895 MW. Between 2008 and 2012, the Shipshaw powerhouse was rehabilitated and expanded to produce 1,145 MW of power (Wikipedia).

[26] Overview of the Chute-à-Caron and Shipshaw projects.



View of the Chute-à-Caron (left) and the Shipshaw (right) projects. During construction of the Shipshaw project, the entire Saguenay River flowed eastward through the Chute-à-Caron dam and along its natural channel shown. Therefore, as described by Legget, the five Shipshaw saddle dams and associated powerhouse could be constructed "in the dry," without having to divert the Saguenay River. The width of the image shown is approximately 4 km. North is to the top of the image. (modified from Google Earth 2018)

[27] When the Shipshaw project was completed it was one of the world's largest power generating plants. The project was described in 1943 articles in *MacLean's Magazine* (MacLean's Archives 1943/3/15) and *Popular Mechanics* (Google Books, Popular Mechanics Dec 1943), starting on page 8, past the 56 pages of advertisements!)



An oblique overview, looking upstream over the Shipshaw powerhouse (foreground) and Chute-à-Caron powerhouse (upper left). Date unknown. (photo source Northern Miner website)

Because of their importance to the Allied war effort, during the Second World War, Arvida, the aluminum plant and the associated dams were protected by anti-aircraft batteries.

[28] Bert Younghusband was not one of the authors. The three authors and their papers in the April 1944 issue of *Engineering Journal*, Vol 27, were:

- McNeely DuBose, MEIC, VP Aluminum Company of Canada, "The Engineering History of Shipshaw," pp 194-220
- H.G. Acres, MEIC, President H.G. Acres and Company, "The Design of the Shipshaw Power Development," pp 221-233, and
- Walter Griesbach, MEIC, Chief Engineer, Foundation Company of Canada, "Construction of the Shipshaw Power Development," p 234-249.

[29] Aluminum Laboratories was the research and development arm of the Aluminum Company of Canada.

[30] This talk may have been the same as one that Legget presented at the "Engineering Conference in Soils for Engineers" held at Michigan State College in Lansing, MI, in March 1941. The titles are identical (LAC 4-86).

[31] The liquid limit is the water content at which the behaviour of a particular clay changes from its plastic state to its liquid state. It is determined by a standard laboratory test that was developed by Arthur Casagrande.

[32] "Leda clay" is now referred to as "Champlain Sea clay." It was deposited during the most recent period of glaciation (13,000 to 10,000 years ago) in the Champlain Sea, a marine environment that extended up the St. Lawrence River lowlands from the Atlantic Ocean to northwest of Ottawa and southward from Montreal to the Lake Champlain region of upper New York State. It is now known that the internal structure of the clay, which was deposited in salt water, can become unstable when exposed to fresh water.

[33] Paleobotany is the branch of botany dealing with the recovery, study and identification of ancient plant remains.

[34] Norman William (Bill) Radforth (1912-1999) was Canada's pioneer muskeg researcher. Throughout his life, he was very involved in Canadian and international committee work and conferences that promoted the study of muskeg. Radforth was on the faculty of McMaster University from the 1940s to 1968. In 1968, he became Head of the Department of Biology and Director of the Muskeg Research Institute at the University of New Brunswick (*Canadian Geotechnical Journal*, 1999, Vol 36, No 2, pp iii.).

[35] The Shipshaw project, completed in approximately 18 months between 1941 and 1943, employed a total of approximately 10,000 workers working in shifts around the clock (Wikipedia).

[36] The *Canadian Journal of Earth Sciences*, Canada's premier outlet for publishing geological papers, was first published in 1964.

[37] The Saint James' Club of Montreal, or as it is known today Club Saint-James, was founded in 1857 and is the oldest private business club in Canada (Saint James Club website).

[38] The Windsor Hotel opened in 1878 and closed in 1981. It is often considered as the first "grand railway hotel" in Canada (Wikipedia).

The Windsor Hotel in 1906 (photo source Wikipedia)

[39] Legget presented the Thirteenth Terzaghi Lecture (named after Karl Terzaghi) in San Francisco in 1977. Terzaghi's challenge to which Legget alludes was to integrate geology with soil mechanics (Legget 1979, p 342).

[40] La Tuque, approximately 150 km north of Trois Rivières, QC and the St. Lawrence River, was named after a neighbouring rock formation that resembles the French-Canadian winter hat of the same name. La Tuque dam and hydroelectric generating station was built on the Saint Maurice River between 1940 and 1955. It is currently the 6th of 11 dams on the river, counting upstream from its confluence with the St. Lawrence River (Wikipedia).

La Tuque dam and hydroelectric generating plant (date unknown) (photo source Hydro-Québec website)

Shawinigan Engineering Company was established in 1919 as a subsidiary of Shawinigan Water and Power Company, founded in 1898. Both had their origins in the town of Shawinigan, QC, also on the Saint Maurice River, approximately 40 km north of Trois Rivières. Most of Shawinigan Engineering's work was associated with developing dams and hydroelectric generating plants. Shawinigan Engineering was bought by Lavalin in the early 1980s (Wikipedia).

[41] Forestville, QC, is located on the north shore of the St. Lawrence River. Here the river is approximately 50 km wide, with Rimouski directly across on the south shore of the river. The project to which Legget refers was likely Anglo-Canadian Pulp & Paper's mill constructed in the mid-1940s (Wikipedia).

[42] Sarnia, ON, is in southwestern Ontario at the south end of Lake Huron. The Polymer Corporation, a war-time-formed federal crown corporation, constructed its plant between 1942 and 1943. Ironically, the artificial rubber was produced using a German patent from an American licensee (Wikipedia).

Sarnia Polymer plant, 1944, (photo source LAC, MIKAN 319646, Ronny Jacques)

[43] Clarence Decatur Howe (1886-1960) was an American born civil engineer who moved to, worked and lived in Canada most of his life. In 1935, he entered politics and became a cabinet minister in the Mackenzie King Liberal government. During the war he was Minister of the Department of Munitions and Supply. The C.D. Howe Institute, an economic think tank, is named after him (Wikipedia).

Although today in Canada, the title "the Right Honourable" is reserved for prime ministers, governors general and chief justices, in the 1940s the title was given to prominent Canadians who were appointed to the British Imperial Privy Council. Howe was so appointed after the Second World War for his war-time efforts. Therefore, in this chapter, Legget perhaps should have referred to the Hon. C.D. Howe.

[44] Styrene, or more precisely Styrene-Butadiene, is a chemical compound that when exposed to air, light or heat transforms into a synthetic rubber. The process was originally developed in Germany in 1929 (Wikipedia).

[45] Richard Lankaster Hearn (1890-1987) was a civil engineer (University of Toronto, 1913) and one of a group that was responsible for the growth of the Hydro-Electric Power Commission of Ontario, the predecessor of Ontario Hydro, now Ontario Power Generation. He was also an early partner in the H.G. Acres and Company. The Hearn Generating Station, located on the Toronto waterfront and operated until 1983, was named after him (Wikipedia).

[46] Soil can be stabilized by adding calcium chloride (CaCl). CaCl was traditionally applied to gravel road surfaces to attract moisture and thereby minimize road dust. It was found, however, that applying the correct amount of CaCl, along with other additives such as fly ash (fine particulate residue of burned coal), would create a stabilized road surface, not as durable as asphalt, but much better than gravel.

[47] Such a reference has not been located. The magazine *The Canadian Engineer* is no longer published. The US-based *Roads & Bridges* trade magazine, first published in the early 1900s, is still being published.

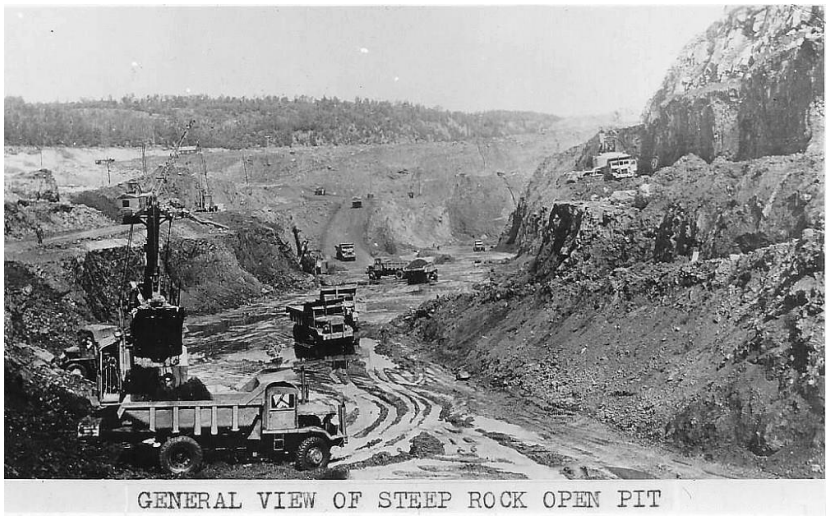
[48] The Aamjiwnaang First Nation, also known as the Chippewas of Sarnia First Nation, is an Ojibwe First Nation located on the Sarnia 45 Indian Reserve. For many years, the approximately 600-700 residents have expressed concern about the proximity of the petrochemical plants that are in the area (Wikipedia).

[49] Hearn, R.L. and Legget, R.F. 1947. "Coal Handling with Earth Moving Equipment," *Transactions of the American Society of Mechanical Engineers*, June, pp 1-5.

[50] Donald Hugh MacDonald (1922-2007) graduated from the University of Toronto in 1945 and was a student of Legget's. He subsequently studied at Cornell University and Imperial College on an Athlone Scholarship, finishing with a PhD from the University of London in 1953. Besides working on the project that Legget describes, he worked with Legget on the early stages of the Toronto subway project. In

1955, he joined H.G. Acres and Company, eventually becoming its president. He was awarded the 9th CGS R.F. Legget Award in 1978 (CGS website; Lives Lived).

[51] Atikokan, ON, is approximately 200 km west of Thunder Bay. In 1938, iron ore was discovered beneath Steep Rock Lake, a few kilometres west and north of Atikokan. One year later, Steep Rock Iron Mines Limited was formed. Initial underground mining attempts were flooded out. Because of the war, when the demand for iron ore was high, it was decided to divert the Seine River so it wouldn't flow through Steep Rock Lake, then dam and drain the lake, then remove 100 metres thickness of glacial sediment to reach the ore (Sunset Country website).



Mining the iron ore from beneath what was Steep Rock Lake, date unknown

Aerial view of the Steep Rock Iron Mine in 1974
(photo source for both, CGS Canadian Geotechnical Achievements 2017)

[52] The Caland Ore Co Ltd was formed in 1949 as a wholly-owned subsidiary of the Inland Steel Company of Chicago. In 1953, Caland signed a 99-year lease with Steep Rock Iron Mines. Both Steep Rock Iron Mines and Caland had ceased operations by 1980 (Caland Freeservers website).

[53] Varved clay is glacial lake sediment characterized by fine (clayey) sediment, deposited during lower energy winter months, interbedded with coarser (silt and/or sand) sediment and deposited during higher energy summer months.

[54] The paper to which Legget refers is Hardy, R.M. and Legget, R.F. 1960. “Boulder in Varved Clay at Steep Rock Lake, Ontario, Canada,” *Bulletin of the Geological Society of America*, Vol 71, pp 93-94. Not mentioned by Legget is another paper about Steep Rock Lake he coauthored with a Steep Rock Iron Mine geologist, Melville W. Bartley: Legget, R.F. and Bartley, M.W. 1953. “An Engineering Study of the Glacial Deposits at Steep Rock Lake, Ontario, Canada,” *Economic Geology*, Vol 48, pp 513-540.

[55] Although it may have originated as Royal Society of Canada Special Publication #3, it was published by the University of Toronto Press (see Chapter 16).

[56] “Both cases” to which Legget refers are the Steep Rock Iron Mine Limited and the Caland Ore Co ltd.

[Chapter 12:] THE POST-WAR YEARS (1945-1947)

As the war neared its end, there was a good deal of sound thinking and planning for the future in Canada, largely stimulated by Rt. Hon. C.D. Howe whose early appointment as Minister of Reconstruction (amongst other things) was one of the Government's wisest moves.[1] Reconstruction Committees at the top level were established at the national level under Principal James (of McGill University) *[for Quebec]*,[2] and Principal Wallace (of Queen's) for Ontario. I think that the record would show that the Ontario Committee was the more effective.

In keeping with these moves of a major nature, I was approached by some of the engineers who had seen, during war jobs, what Soil Mechanics (as it was then called) had to offer. Dr. R.L. Hearn was one, I know, but there were others. Their request boiled down to the same general message—when they graduated, Soil Mechanics had not been thought of. They could see its value and wanted to be able to use this new approach to soils; would I not put on a Short Course at the University so that they could at least learn the elements *[of the topic]*.

As can be well imagined, I was not looking for things to do but the requests were so insistent and from such notable men that I discussed the matter with C.R. Young, still my mentor even though (I think) he was now Dean;[3] the Department had a head who had been away for much of the war and who was not interested in the practice of civil engineering.[4] C.R. agreed that it really should be done so I got busy and planned a five-day (week-long) course of lectures, with simple laboratory sessions in the evenings.

When I had this ready, and in conjunction with the University's Extension Department, we placed a note about it in the *Daily Commercial News,* the excellent construction newspaper published in Toronto.[5] Within 24 hours, the course was sold out to our amazement. We had to limit the number of registrations to something like 150, the capacity of the largest lecture room in the Electrical Building (in which the Dept, of Civil Eng. was located). I had grave doubts about reserving such a large room, so modest were my expectations. I need not have worried. What was even more surprising was the calibre of the registrants—Dr. Hearn's was one of the first to be received and he was then General Manager of Ontario Hydro[6] at the start of its great era of expansion; Otto Holden[7] was another; heads of several consulting firms...so it was going to be a meeting of friends. It was held from 14 to 18 May 1945.

I had invited one or two close friends to do individual lectures—Lyman Chapman was one, I think, from the Ontario Research Foundation.[8] But here, in matters of detail, my memory fails me. As I must record with great embarrassment, such was my disregard for the history of Geotechnique in Canada or at least about my part in it, that when some years ago, the Norwegian Geotechnical Institute issued a call for early records of Geotechnique for *[its]* Terzaghi library, I was stupid enough to send over to them my complete notebook for this course. This contains all my lecture notes (simple as they were) and copies of the publicity and

registration forms etc., with (I think) a list of registrants. I am so mad with myself for having done this that, after this has been read and if others think it worthwhile, I will gladly write to NGI and ask for my notebook back; let's hope they still have it.[9] In summary, all I can record is that the week was, as far as I could see, a success, judging by the comments I received. Certainly I was encouraged, attendance staying at almost 100 per cent to the last hour on the Friday.

As a necessary aside, but to show how thinking was developing, on 13 March 1945, I had an interview with J.P. Miller, the Deputy Minister of the Ontario Department of Highways. With the full approval of C.R. Young, I placed before Mr. Miller the idea of a post-war joint University-Department of Highways Research unit, similar to the pioneer project so successfully operated by Purdue University and the Indiana Highway Department. The Purdue Joint Project was a real pioneer in the highway research field. I had seen it in 1940 and kept in touch with its work, the beginning of a long relationship with Professor K.B. Woods.[10]

Miller turned me down flat, even going so far as to say that he was not interested in "messing about with mud" when I tried to tell him what Soil Mechanics could then do in Highway design and construction. So that was that; I have often wondered what might have developed had there been someone for me to talk with other than Mr. Miller. For entirely different reasons, Mr. Miller ceased to be the Deputy Minister not too long after this visit. A new Deputy Minister was appointed and the Department started on its post-war programme which was carried out with such distinction—and with all the aid that Soil Mechanics could give, as I watched with unusual interest from afar in Ottawa![11]

Meantime, other things were happening as hopes about the end of the fighting escalated. Late in 1944, I got a telephone call from Major H.W. Tate,[12] assistant General Manager of the Toronto Transportation Commission (as it then was), an almost mythical character and a great man. He was reputed to have known the name of every employee of the TTC. Certainly, when I went round with him, he would speak to all the men we saw by name—and they worshipped him! He was a man of vision; happily he lived to a great age and so was able to see more than the fulfillment of some of his dreams. He asked me to come and talk to him, which I did, finding that the Commission, under his urging, had agreed to start studies for a subway. I said that I thought that Toronto was not yet ready for such a development. He said that it would be ten years before any subway would be ready (right on the nose; it was exactly ten years from the day of our talk) and that, by then, Toronto would be ready. He was absolutely right; I was equally and completely wrong!

So "H.W." wanted to know how you started to find out about ground conditions in which the subway would be built, ending up by asking if I would be consultant to the TTC for the study. C.R. Young agreed and so began one of my most rewarding consulting jobs. Being so close to the University, it was easy to fit in with my University duties, necessitating no absences from classes.

I went first to the City Hall and asked if I could see their records of the urban geology. They did not know what I was talking about and had precisely nothing. So began my interest in Urban Geology, still developing so many years later![13] I had to get busy and study the few reports available from the Ontario Department of Mines, notably by the great Dr. A.P. Coleman;[14] then I went round to all interested consulting engineers and solicited their help, always gladly given. I discovered that one consultant, Gordon Wallace (later the firm of Wallace and Carruthers[15]), in order to keep his small staff busy during the depression, had kept them busy studying old city records and plans, on the basis of which the office had prepared a fine map of all the ravines that once interlaced the whole area now occupied by the city. The main ravines are still there; the smaller ones have all been covered up. This was a real find and most helpful. (It has not yet been published but has been used—I think—by Owen White and his staff in the Ontario Geological Survey.[16])

The overall pattern of the underlying geology gradually developed but the Commission accepted my recommendation that, despite this, test borings must be put down to confirm what we thought the geology was. There were no test boring companies at that time but my friends in the Department of Public Works, Canada, very kindly arranged for one of their rigs to be rented to the Commission for this clearly urgent work.

In locating the test holes, I made another "discovery" of the consultative committee that maintains the detailed records of all underground utilities in Toronto, meticulously kept and, as we discovered, accurate to within an inch or less. The borings were put down, confirming the overall picture; one was drilled deep enough to tap sub-artesian water, of which I had been told, that had caused "quicksand"[17] in one of the deep foundations. A few holes were cased and groundwater levels read regularly for over a year, giving absolutely vital information. (In one we found gasoline, to general consternation, until it was traced to a leaking tank at a filling station[18]). Samples of all soils encountered were carefully kept and cores of the underlying shale.

The Chief Engineer to the Commission for the subway work accepted my suggestion that not only should essential subsurface information be fully integrated into the contract drawings and documents, but that all the information we had obtained should be made available to all those tendering on the work. At the time, this seemed to me to be just plain common sense but we soon discovered (from the comments of tenderers) that it was so rare a procedure as to be phenomenal! Today it is a fairly regular practice—but the efficacy of this early example was shown when the tenders came in, all very close to one another and to the engineer's estimate; *[and]* also by the final settlement of the contract, with no difficulties about major claims, the entire matter settled in one happy session in the Chief Engineer's office between him and the General Manager of the contractor's consortium. The material was very well displayed in a separate room set aside for this purpose in the old TTC head office building.[19] (I was then in Ottawa and so had nothing to do with the final arrangements.)

I venture to give these details because of another real "blind spot" of mine. At the time, I gave no thought to the fact that this was pioneer work, and that the example of what we did for the first Toronto subway might be of help and service to other Canadian cities when they came to build their subway...and so I did not "write it up" at the time. I can offer many excuses, the main one being that I was so very busy—with University work and the Ottawa research work, yet to be mentioned—but the fact remains that this was an opportunity missed.

Another factor in the overall picture was that the Advisory Geological Committee, to which the TTC willingly agreed, did not function quite as effectively as we had hoped. One key man died tragically while work was in progress; another proved to be quite uncooperative, to our total surprise. Some geological papers did result from the work but not the series of papers which the Advisory Committee had originally envisaged. The concept of the Advisory Committee remains (in my view) a sound one, well worth adopting on other major comparable construction jobs.[20]

To this I should hasten to add that, when excavation did start, we made certain that regular suites of soil samples (at every 50 feet, I think) were taken and carefully encased, being eventually passed to the Royal Ontario Museum for safe keeping, and to be available for future workers on the Pleistocene Geology of Toronto. I think (and hope) that they are still there.[21]

This *[drilling]* job was supervised by W.R. (Bill) Schriever,[22] of the newly formed Division of Building Research *[of the National Research Council (DBR/NRC)]*, who was assigned as subway research officer, resident in Toronto, throughout the excavation part of the first contract. This followed my departure for Ottawa in the early summer of 1947. When I came to advise the TTC about the necessary break in my connection with them, they urged me to keep in close touch with the work and offered any facilities I wanted when I had got the new Division launched. Thus it came about that having a research officer right on the subway work was to the pleasure of the TTC, and in keeping with my resolve to develop building research in Canada in the closest possible liaison with construction operations as well as with design professionals.

Towards the end of the 1950s, with Bill Schriever back in Ottawa, I finally realised my mistake in not having written up the TTC work and so we put together a summary paper. [A] There was still no Canadian outlet for such papers and so I made another error, by sending it to a British trade journal, the Editor of which had been "after me" for some years for a paper on some aspect of the work of DBR/NRC. Even though a summary paper only, it should have been published in Canada; that it was not, has long been a matter of regret to me. But we had to wait until 1963 before we had our own journal.[23]

It will have been obvious that my connection with the Toronto subway overlapped my move to Ottawa but I have included it here for convenience. Work at the University of Toronto continued to occupy almost all of my time. We had the first classes of ex-service men in 1944

[A] Legget, R.F. and Schriever, W.R. 1960. "Site Investigation for Canada's First Underground Railway (the Toronto Subway)," [UK] *Civil Engineering*, January, pp 55-71.

(what a joy it was to lecture to them). Then came the huge influx, the start of the satellite campus,[24] journeys to which necessitated 7:00 a.m. starts, but it was an exciting and challenging time. It left little opportunity for any outside activity, but two more special consultancies must be in this record.

The end of the war saw the building of the first new hospitals in Canada for many years. One of these was the first (main) section of the new Sick Children's Hospital of Toronto on University Avenue. The architect was "Jimmy" Govan, a small Scots Canadian with real expertise in hospital design, and a delightful man.[25] He was anxious, as always, to do a first class job.

I cannot recall who was doing the structural design for the building (possibly in his own office; memory fails me) but there was the usual talk about piles. Mr. Govan had a hunch that this was wrong and so asked me to help. It did not take long to find that the site was underlain by till, nor to have this checked by one or two test holes; even they confirmed the presence of boulders. I did some shear tests on the till and was able to show that a floating concrete slab foundation would be perfectly safe. "Never done before in Toronto" was the immediate reaction; Mr. Govan had to take a lot of "flack" but he stuck to his guns, designs were completed and the contract let.

When the Hospital's Board of Directors (mainly financial men from "downtown" because of the big fund-raising effort) heard that the building was to "float" and not be firmly founded on piles, there was consternation. Over Mr. Govan's head, they consulted Stone and Webster who, with their financial connections, had just established their Canadian Office.[26] They had to refer the matter to their Boston head office; in due course I had to waste a lot of my time telling men from the S&W office the basis of the design. Well after a year from when they were consulted, they submitted their report, which Mr. Govan and I did not see but which, apparently, confirmed all aspects of the design since nothing more was heard about piles.

The building was, I think, the first major building in Toronto to be so founded; it was soon followed by others including the Mount Sinai Hospital on the other side of University Avenue. Study of its settlement was one of the first field investigations by the new Division *[of Building Research]*. The results were well written up by Carl Crawford and Ken Burn and, in their paper, they refer briefly to the similar studies at the Sick Children's Hospital.[B] I am fairly sure that stainless steel plugs will be found embedded in the "Sick Kids" basement columns, if ever anyone has the time and inclination to look!

From the numerous other small consultancies—all involving just my advice and nothing in the way of design in keeping with C.R.'s guidelines—one only can be mentioned since it was a unique assignment.

[B] Crawford C.B. and Burn K.N. 1962. "Settlement Studies on the Mount Sinai Hospital, Toronto," *Engineering Journal,* Vol 45, pp 31-37, December 1962.

Just after the end of the war, Ontario Hydro was able to complete two long-planned diversions of water into Lake Superior from the Nelson River watershed, draining into Hudson Bay. One of these (the Long Lac diversion, I think) increased the flow of the Aguasabon River, entering Lake Superior at Terrace Bay,[27] to such an extent that it was economical to develop power at the ideal site near the river's mouth. By constructing a small dam in a rocky gorge, the water level of the impounded reservoir was such that it flooded through a narrow defile[28] into a huge area, the southern edge of which was only about half a mile (or less) from the shore of Lake Superior. A concrete intake structure could be built on bedrock from which a tunnel in rock could be driven to near the lakeshore where short penstocks could lead to a small power house, discharging almost directly into the Lake.[29]

It really was, and is, a beautiful little water power project. It was planned and construction was well started while Hydro, with their usual care, carried out a massive programme of test drilling along the ridge which separated the reservoir from the lake, on which was located the main line of the Canadian Pacific Railway (and now the Trans-Canada Highway). Test drilling was difficult through the sand and gravel because of the presence of boulders, but the work was pressed forward.

First one, then several holes were completed, all in sand and gravel, but they went well below the level of the Lake without striking bedrock. Reaction of Ontario Hydro managers can be imagined; there was fear that, despite all the work completed, the entire project might have to be abandoned.

Dr. Hearn was General Manager *[of Ontario Hydro]*. One day he called me and asked if I would go and have a look at the site to see what I thought. (I was told, later, that this was the first time in their recent history that Hydro had gone outside their own staff for engineering advice). I went up to Aguasabon and had a very good look round the entire site, ably guided by John Gorman. It seemed pretty hopeless but after "sleeping on it" I had another look and asked myself why there was a small lagoon ("Blue Jay Lake") in the centre of the depression to be filled by the reservoir. It was not very large, or deep, being surrounded by marshy ground. Then I recalled the changing level of Lake Superior since the *[glacial]* ice receded, so well shown by the terraces after which the Bay is named, so I wondered if beneath Blue Jay Lake there might not be the bed of an old glacial lake.

It did not take us long to find out that there was blue clay-silt, clearly impermeable, all round the little Lake. Auger borings showed it to be two or three metres deep; later exploration, with all holes very well carefully plugged up, confirmed its existence over the whole area to be occupied by the impounded water, just as if Nature had arranged it specially. Nobody could be absolutely sure that the clay lining (so to speak) was continuous but it was decided to take a chance and carry on. I shall never forget the worry of waiting for the first reports of observations in the wells, specially cased, as the water level of the reservoir rose. There was a slight rise of groundwater level some 100 metres beneath the reservoir, but this soon stabilised and the plant

has been in operation ever since. And this time, so unusual was the case, I did write it up, but again, of necessity, in an overseas journal.[C 30]

[C] Legget R.F. 1953. "A Perched Reservoir in Northern Ontario, Canada," *Geotechnique*, Vol 3, pp 259-265.

Annotations Chapter 12: THE POST WAR YEARS (1945-1947)

[1] Canada established the Department of Reconstruction in June 1944, before the end of the Second World War, to help promote industrial output and to maximize employment once the war was over. Howe was appointed the minister of the department, while retaining his war-time position as Minister of Munitions and Supply. In late 1945, after the war, the two departments merged to become the Department of Reconstruction and Supply (War Museum Canada website). Howe is introduced in Chapter 11 and its annotations.

[2] Frank James (1903-1973) was Principal of McGill University from 1939-1962. He was born in London, England and attended the London School of Economics and the University of Pennsylvania, receiving his PhD in 1926 (McGill University website).

[3] Clarence Richard Young was introduced in chapter 8 and 10 and their annotations.

[4] This individual was T.R. Loudon, Professor of Civil Engineering and Aeronautics, who served as Department Head of Civil Engineering (Municipal and Structural) from 1945 to 1954. He was a faculty member from 1907 to 1954. While at U of T, Louden was very involved with athletics and helped design the University of Toronto's Varsity Stadium and Varsity Arena in the 1920s. For three years during the Second World War he was on war leave from the university and served as a RCAF wing commander. After the war, Louden was awarded the British Empire Efficiency Decoration (VD) in recognition of his long and meritorious service as a part-time commissioned officer (University of Toronto website).

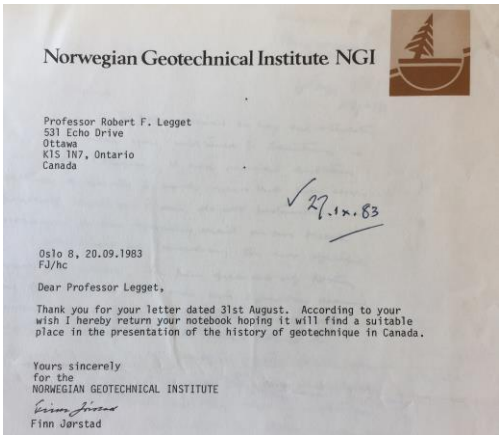
[5] The *Daily Commercial News* was founded in the mid-1930s and is still published in both print and online. According to its website, it "has been the leader in providing essential construction news, project leads and tender information to eastern Canada's construction marketplace."

[6] In 1945, Ontario Hydro would have been known as the Hydro-Electric Power Commission of Ontario. See annotations in Chapter 7 for more information on Ontario Hydro.

[7] In 1945, Otto Holden was the General Manager of the Hydro-Electric Power Commission of Ontario. The Otto Holden Generating Station on the Ottawa River, a short distance north of Mattawa, is named after him (Ontario Power Generation website).

[8] Lyman J. Chapman graduated from Ontario Agricultural College (now affiliated with the University of Guelph) in 1930. From 1932 to 1973, he was a research fellow and Director of the Physiography Department of the Ontario Research Foundation, an Ontario government crown corporation. Chapman was co-author, with D.F. Putnam, of *Physiography of Southern Ontario*. The first edition was published in 1951 and then republished in 1966 and 1984. The Lyman J. Chapman Library at the University of Guelph is named after him (University of Guelph website).

[9] Shortly after Legget wrote his memoir, he did contact the Terzaghi Library at the Norwegian Geotechnical Institute (NGI) and asked for the return of his course notes and associated materials. They returned his "notebook" in September 1983. However, a recent search for this material in the Libraries and Archives Canada, the NRC Archives, the University of Ontario Technical Institute's National Engineering Archives and the University of Alberta Archives turned up nothing.



Norwegian Geotechnical Institute NGI

Professor Robert F. Legget
531 Echo Drive
Ottawa
K1S 1N7, Ontario
Canada

✓27.IX.83

Oslo 8, 20.09.1983
FJ/hc

Dear Professor Legget,

Thank you for your letter dated 31st August. According to your wish I hereby return your notebook hoping it will find a suitable place in the presentation of the history of geotechnique in Canada.

Yours sincerely
for the
NORWEGIAN GEOTECHNICAL INSTITUTE
Finn Jørstad
Finn Jørstad

Letter from Finn Jorstad of the NGI to Legget with regards to returning the material associated with his 1945 short course on Soil Mechanics. The numbers/letters “27.IX.83” indicate that Legget responded to this letter on September 27, 1983. (LAC 3-17)

[10] Legget saw this cooperation when he attended the Purdue Conference on “Soil Mechanics and its Applications” in 1940 (see Chapter 11).

K.B. Woods was a professor, then Professor Emeritus of Lyles School of Civil Engineering at Purdue University, Lafayette, IN. He was the 19th Chairman of the (US) Highway Research Board (now known as the Transportation Research Board) and was active in the affairs of the board throughout his career (US Transportation Research Board website).

[11] During the 1950s, Alex Rutka was the Principal Soils Engineer of the Ontario Department of Highways. Under his leadership the department flourished. Rutka was a 1947 civil engineering graduate of Queen’s University then joined the department where he worked his entire career until he retired in the early 1980s. In 1984, he was presented with a Distinguished Service Award by the Transportation Association of Canada.

[12] Harry William Tate (1884-1974) graduated as a civil engineer from the University of Toronto in 1909. He served overseas with the Royal Canadian Engineers during the First World War. During the Second World War he helped select and train engineering officers, for which he was awarded the MBE (Member of the Most Excellent Order of the British Empire) in June 1946 (University of Toronto Alumni website).

Tate worked with the Toronto Transportation Commission (now the Toronto Transit Commission) from 1920 to 1954. As assistant general manager he was instrumental in getting the initial Yonge Street “rapid transit subway” (as it was then known) line constructed between 1949 and 1954 (Toronto Transit Commission website).

Toronto’s Yonge Street subway under construction, using the cut and cover method of construction in the late 1940s (photo source City of Toronto Archives, Series 381, s0381_80015_id6207-3)

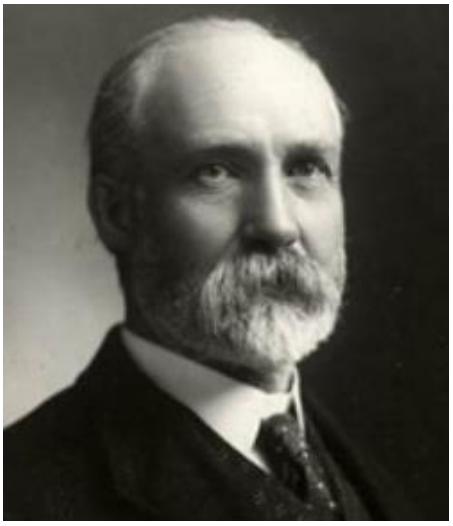
[13] As will be mentioned later, in 1973, Legget published his 624-page textbook *Cities and Geology*.

[14] Arthur Philemon Coleman (1852-1939) studied geology and natural history at Victoria College in Cobourg, ON, then received his PhD from the University of Breslau (a German University in what is now Poland) in 1881. During his long career, he taught at various times at Victoria College, the School of Practical Science in Toronto and the University of Toronto. Between and in parallel with his academic career, he was a geologist with the Ontario government, retiring in 1934 at the age of 82!

Coleman did not limit his work to Ontario. He was a member of numerous European, Arctic and Canadian Rockies geological expeditions. He was a team member of the first ascent of Castle Mountain, AB, and the first attempt to climb Mount Robson, BC. In 1939, the year he died, he had planned to carry out geological work in British Guiana (now Guyana).

Coleman was honoured by many national and international science and geological organizations and received four honorary doctorates. He was the first Canadian to be President of the Geological Society of America (Legget was the second). In his later years, he was recognized as the "Dean of North American Geologists" (Wikipedia).

With regard to Legget's research on the geology of Toronto, he referenced Coleman's 1913 "Map of Toronto and Vicinity," the first comprehensive geological map of Toronto, and the map "The Pleistocene of the Toronto Region" by Coleman and A. MacLean (1933), both prepared for the Ontario Department of Mines.



Dr. A. P Coleman from his February 27, 1939 *Globe and Mail* obituary.
Legget had it in his personal files. (photo source LAC 18-19).

[15] The firm Carruthers & Wallace was a well-known Toronto structural engineering company responsible for, among other Toronto landmarks, the Canadian National Expedition Stadium, the Eaton Centre, the Royal Bank Building and Roy Thompson Hall. In 2005, it joined the Trow Group of Companies, now known as exp Global Inc (exp Global website).

[16] Australian-born Owen L. White (1926-2018) was a prominent Engineering Geology/Geotechnical Engineer in Canada. After teaching at the University of Waterloo in the 1960s and 1970s, he became Chief of the Engineering and Terrain Geology Section of the Ontario Geological Survey in 1977, a position he held until he retired in the early 1990s. White served as President of the International Association of Engineering Geology from 1986-1990. He was awarded the 37th CGS R.F. Legget Medal in 2006 (CGS website; Lives Lived).

Recent correspondence with the Ontario Geological Survey turned up nothing with respect to the document to which Legget refers. However, Figure 9 in the 1998 paper "Urban Geology of Toronto and Surrounding Area" by C.L. Baker, L.R. Lahti and D.C. Roumbanis, is a partial reconstruction of the distribution of historical streams and rivers in the Toronto area and is based on a 1951 City of Toronto

Planning Department unpublished map. This paper is published in the Geological Association of Canada's Special Paper 42, edited by Paul Karrow and Owen White. This 1951 map could be the map to which Legget refers.

There is an interactive map of the disappearing rivers of the Toronto area at www.LostRivers that captures the period from 1807 to 2017. The historical map-base for this interactive map is Coleman and MacLean's 1933 map "The Pleistocene of the Toronto Region."

[17] Quicksand is a saturated loose sand that, when agitated or when the upward flow of the water within the sand is greater than the force of gravity, creates a liquefied soil that cannot support weight.

[18] Until recently, gasoline leakage from underground tanks was a major source of groundwater contamination. In North America, starting in the late 1970s and continuing to the present, this problem and its remediation have resulted in the development of a specialized branch of environmental hydrogeology.

[19] From 1921, when the TTC was formed, until 1957, its head office was in the seven storey Toronto Board of Trade Building on the corner of Front Street East and Yonge Street in downtown Toronto. When this building was constructed in 1892, it was one of the tallest buildings in the city. It was demolished in 1958 causing the TTC to move its head office to The William McBrien Building at Davisville and Yonge streets (Wikipedia).

Early 1900s photo of the Toronto Board of Trade Building, head office of the TTC from 1921 to 1957
(photo source Wikipedia)

[20] Advisory committees or review boards have now become common for most large construction or development projects.

[21] A recent inquiry of the Royal Ontario Museum has not yet determined whether it still has the soil samples to which Legget refers.

[22] William Robert (Bill) Schriever (1921-2018) was a Swiss-trained civil engineer who graduated from Arthur Casagrande's master's program in soil mechanics at Harvard University in 1948. Upon graduation he immigrated to Canada and starting working for Legget at the NRC's Division of Building Research. His first assignment was to represent the NRC/DBR in Toronto during the construction of the TTC's Yonge Street subway. He eventually focused his research on buildings and snow loads and became Head of the Building Structures Section of the NRC/DBR (*Ottawa Citizen* Obituaries website). He is mentioned again later in Legget's memoir.

[23] In 1960, Legget could have published this paper in the EIC's *Engineering Journal*. He had published a number of other geotechnical papers in that journal prior to 1960.

[24] After the Second World War, the Canadian government wanted to encourage more engineering training. With federal support, the military munitions plant at Ajax, ON, approximately 45 km east of the

main University of Toronto campus, was converted into lecture rooms and laboratories. First- and second-year classes were held there from 1946 to 1949 (University of Toronto Alumni website).

[25] James (Jimmy) Govan (1882-1963) was a Scottish-born and trained architect. He moved to Toronto in 1907. During his career he specialized in designing hospitals. His and his partners' designs can be found in every province in Canada except British Columbia, and in some US cities. His firm, Govan, Ferguson and Lindsay, designed Toronto's Hospital for Sick Children and Mount Sinai Hospital among many other hospitals (Dictionary of Architects in Canada website).

[26] Stone & Webster, founded in 1889, was a large Massachusetts-based engineering, construction, environmental and plant operation company. In 2000, it was acquired by the larger Shaw Group based in Baton Rouge, LA (Wikipedia).

[27] Legget has his geography a little confused. The Long Lake Diversion, completed in 1939, diverted water from the headwaters of the Kanogami River (which flowed into the Albany River, then into James Bay) so that it flows into the Aguasabon River, then into Lake Superior. That diversion project, located approximately 130 km north of Lake Superior, is described in a 1980 Canadian Water Resources Journal paper by S.E. Peet and J.C. Day.

[28] A defile is a somewhat archaic word for a narrow passage way, canyon or gorge.

[29] Construction of the Aguasabon Hydroelectric Power project near Terrace Bay, ON, began in 1946 and was completed in 1948. Terrace Bay is located along the north shore of Lake Superior, approximately 200 km east of Thunder Bay, ON (Ontario Power Generation website and Wikipedia).

View of the Terrace Bay area and the Aguasabon Hydroelectric Power project. The dam is located on the Aguasabon River, approximately 1.5 km north-northwest of the community of Terrace Bay. The 'defile' to which Legget refers is the narrow east-west trending body of water that connects the Aguasabon Reservoir and Hays Lake (formerly a lagoon called Blue Jay Lake). The power house is approximately 3.5 km west of the community. The tunnel from Hays Lake to the power house on the shore of Lake Superior is approximately 1 km in length. The width of the image shown is approximately 11 km. North is to the top. (photo modified from Google Earth 2018)

[30] *Géotechnique*, published by the (UK) Institution of Civil Engineers since 1948, is the premier geotechnical journal in the world.

Chapter 13: UNIVERSITY YEARS IN CANADA (1936-1947)

This chapter provides additional information on Robert Legget while he worked at Queen's University and the University of Toronto.

Legget left his position as a civil engineer with the Canadian Sheet Piling Co Ltd, and moved from Montreal to Kingston, in September 1936. For most, if not all, of the almost two years that Legget worked at Queen's University, the Legget family lived at 109 William Street in Kingston.[1]

109 William Street, Kingston, ON, is on the right side of the photo. (photo by Dave Gauthier 2019)

As a lecturer in the Department of Civil Engineering, Legget helped Alexander (Sandy) Macphail teach his second-year course, "General Engineering 1"—a core course for all second-year engineering students. From the Queen's 1936-1937 calendar:

> This subject embraces the physical properties of materials used in the different branches of engineering and the principles involved in the theory of beams, columns, and structures, and involves modules on materials of construction, graphical statics and mechanics of materials.

Legget described his involvement with this course in his 1971 *Queen's Review* article "Sandy Macphail 1870-1949," which he references in Chapter 10:

> The second-year class in engineering was to be so large, and the size of the largest lecture room in the original Carruthers Hall was so limited, that Sandy's famous lectures on 'General Engineering One' would have to be given three times every Tuesday and Thursday. Dr. Wallace explained this to me so kindly at the small meeting when I was appointed, and observed that I would have a splendid introduction to University teaching by listening to Dr. Macphail give his first lecture, then [I would be] repeating it to the second and third sections of the big class.

> As we walked away [from the meeting with Dr. Wallace], Sandy gripped my arm under the elbow (one of his pleasant traits when he wanted to speak with emphasis) and said, 'I'm quite sure, Legget, that Dr. Wallace is going to be a fine Principal. He's clearly a very good man but he really doesn't know very much about teaching. Now, I'll tell you how we are going to work together. When I come in on Tuesdays and Thursdays, I'll take all three lectures if I feel up to it. And if I don't, then you can take the lectures.' And so it was. Throughout the two sessions in which I had this happy privilege, I did not know if I would be giving the lectures until two or three minutes before the first lecture was due to begin, when Sandy made up his mind as to how he felt. Having always to be prepared, I can image no better training for University work.

Left: Carruthers Hall, Queen's University (photo source Google Street View 2019)
Right: portrait of Alexander (Sandy) Macphail (photo source Queen's Review 1971)

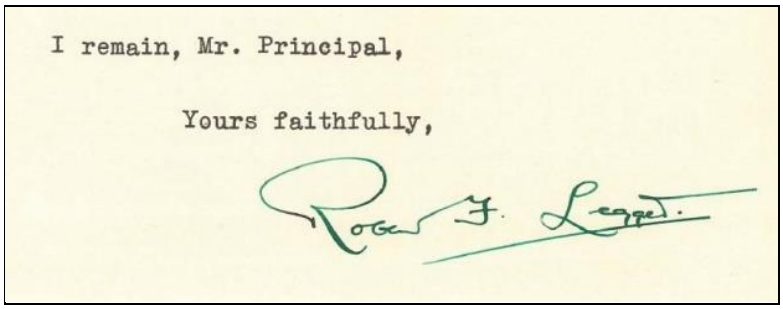
Besides assisting Macphail with his teaching and setting up a soil mechanics laboratory, Legget also spent a lot of time writing. During his 21 months at Queen's he wrote seven general construction articles (some, the result of his work with Canadian Sheet Piling), five general engineering articles, two articles of general interest, one article related to geotechnique, one article related to railways and one on the St. Lawrence River. The latter was published in *Saturday Night.*[2] The geotechnical article was entitled "Importance of Soil Studies as Part of Civil Engineering Work" and was published in *Engineering & Contract Record*. One of the general engineering articles was on the "Semicentennial of Canadian Engineers," Legget's first of what would be many articles on the history of Canadian engineering.

During this period at Queen's, Legget spent much of his time writing the first draft of what would be his 650-page textbook, *Geology and Engineering* that would be published in 1939.

Continuing his tradition of joining organizations, while at Queen's, Legget became registered as a Professional Engineer with the Association of Professional Engineers of Ontario (now Professional Engineers Ontario) and an Associate Member of the American Society of Civil Engineers.

As described in his memoir, in the spring of 1938 he decided to accept a position at the University of Toronto. His May 1938 letter of resignation to Queen's Principal Wallace provides an example of Legget, the gentleman.

> …My desire to take this post at [the University of] Toronto arises from the nature of the work which I shall there have to do, and from the opportunities which it will present for keeping in close touch with civil engineering practice, and for seeing something of the working of another University, experience which will be valuable in view of my desire to continue academic work….
>
> …May I add that my two sessions of life and work at Queen's have been wholly delightful. Before this unusual and unexpected invitation came to me from Toronto, I had ventured to look forward to spending a long and happy time at this University…


I remain, Mr. Principal,

Yours faithfully,

Roger J. Legget.

From Legget's May 11, 1938 letter of resignation from Queen's University (Queen's University Archives)

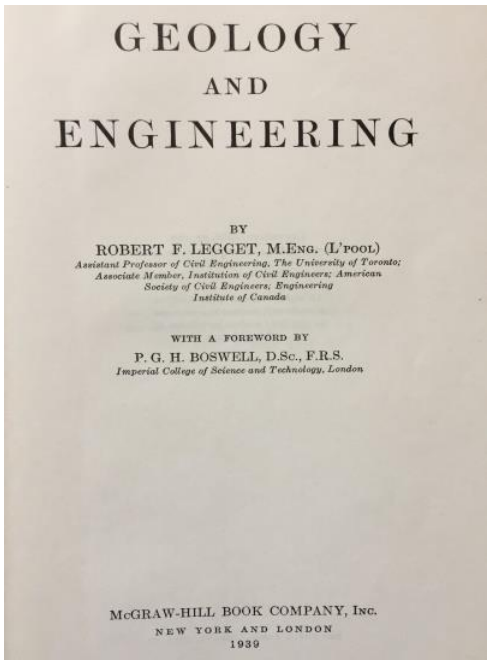
Legget was offered an assistant professorship at the University of Toronto, whereas at Queen's he was one rung below—a Lecturer. This was probably one reason why he accepted the position in Toronto. Another reason, mentioned in his resignation letter to Principal Wallace, was "the nature of the work which I shall there have to do"—to further develop his knowledge in soil mechanics, with which he was "inspired" when he left the 1936 International Conference.

At Queen's at that time, soil mechanics was mentioned as only one of many topics in the 4th-year course "Highway Engineering." U of T, however, had established a course in "Foundations, Retaining Walls and Dams" as early as 1922 and had started a course in "Soil Mechanics" in the fall of 1936. This latter course was taught by the same C.R. Young who wooed Legget to U of T, was Head of the Department of Civil Engineering (Structural and Municipal Division) and who attended the 1936 International Conference.

During the 1940s, after Legget had left Queen's, the subject of soil mechanics at that university continued to develop slowly, while at U of T it developed quite quickly, both in the classroom and, thanks to Legget, in the laboratory. Therefore, to further develop his knowledge in soil mechanics, it appears that Legget made the right decision to leave Queen's for U of T. Alternatively, however, if he had stayed at Queen's, Legget might have been influential in helping to develop soil mechanics more quickly at that university.

For the first session at U of T (1938-1939), besides teaching, setting up his soil mechanics laboratory and doing some consulting, Legget completed his textbook *Geology and Engineering*. This involved finishing the first draft (started while at Queen's), finding and obtaining the rights to use the photos and illustrations, then submitting this draft to McGraw-Hill in New York, making revisions, resubmitting it and then proofreading the last draft. He wrote his acknowledgements in

June 1939 and the book was published that summer. It sold in North America for $4.50 and in the UK for 24/9 (24 shillings and 9 pence), approximately CDN$80.00 in 2020.



GEOLOGY
AND
ENGINEERING

BY
ROBERT F. LEGGET, M.Eng. (L'pool)
Assistant Professor of Civil Engineering, The University of Toronto; Associate Member, Institution of Civil Engineers; American Society of Civil Engineers; Engineering Institute of Canada

WITH A FOREWORD BY
P. G. H. BOSWELL, D.Sc., F.R.S.
Imperial College of Science and Technology, London

McGRAW-HILL BOOK COMPANY, Inc.
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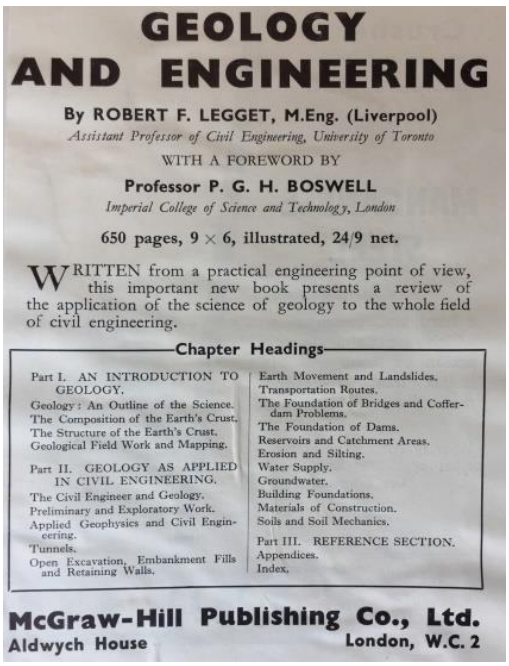
1939



GEOLOGY AND ENGINEERING

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650 pages, 9 × 6, illustrated, 24/9 net.

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Preliminary and Exploratory Work.
Applied Geophysics and Civil Engineering.
Tunnels.
Open Excavation, Embankment Fills and Retaining Walls.
Earth Movement and Landslides.
Transportation Routes.
The Foundation of Bridges and Cofferdam Problems.
The Foundation of Dams.
Reservoirs and Catchment Areas.
Erosion and Silting.
Water Supply.
Groundwater.
Building Foundations.
Materials of Construction.
Soils and Soil Mechanics.
Part III. REFERENCE SECTION.
Appendices.
Index.

McGraw-Hill Publishing Co., Ltd.
Aldwych House London, W.C. 2

Geology and Engineering 1939. Left: title page. Right: advertisement in the (UK) *Civil Engineer*, October 1939 (LAC 10-5)

Having it published was a huge undertaking to be sure. The book begins with the classic Francis Bacon quote, "Nature, to be commanded, must be obeyed." The frontispiece is that of William Smith, an eminent engineer who became known as the Father of British Geology. P.G.H. Boswell, Legget's University of Liverpool geology professor, contributed the foreword.

The book is dedicated "To my wife whose continued encouragement and expert assistance almost warrant the dispelling of this anonymity by the appearance of her name, jointly, on the title page." It is not known exactly how his wife assisted, but considering everything else that was going on in their lives during the gestation period of this book (1934-1939), and considering Mary's background as a secretary for a consulting engineering firm, it is likely that she did, indeed, contribute a great deal.

Despite the book being published shortly before the Second World War, there appears to have been a market. More than 2,000 copies were sold in the first year; 6,000 copies were sold by the end of the war, and 12,600 copies were sold in the first ten years. The textbook received good reviews and, rightly so, the 35-year-old Legget was very proud of his accomplishment.

Following its publication in the fall of 1939, Legget made inquiries to the University of Liverpool as to what was required to obtain a Doctor of Engineering degree.[3] There is no indication, however, that Legget applied.

In the 1930s and 1940s, the U of T Department of Civil Engineering was divided into two separate divisions: Municipal and Structural Engineering, and Surveying and Geodesy, each with a separate division head. Legget was associated with the former, the larger of the two divisions. Between 1938 when he joined, and 1947 when he left, the number of faculty in the two

divisions increased from eight to 22. Most of that increase occurred immediately after the war, when many Second World War veterans were given incentives to attend university. At times during the war, the faculty was reduced to only a few because of “war leaves.”

Legget’s teaching load increased substantially when he was covering for faculty who were on war leave. In the 1938-1941 school years, he taught or co-taught four courses; in 1941-1942 eleven courses; in 1942-1943 nine courses; 1943-1944 eight courses, and 1944-1947 six courses. Over his nine years, the focus of the courses Legget taught gradually shifted from structural to geotechnical.[4]

Legget’s office was in Room 246 of the Electrical (Rosebrugh) Building and he taught his smaller classes in that building. Larger classes were taught in the larger lecture halls in the neighbouring Mining Building (now the Lassonde Mining Building).

Left: front entrance to the Electrical (Rosebrugh) Building. Above: lecture room 128 in the Lassonde Mining Building (photos by Doug VanDine 2019)

Whether lecturing or in the laboratory, Legget was always attired in a white shirt and tie under a brown lab coat. He was a good and popular professor. In 1983, Lionel Peckover, who graduated in 1944 and later worked with Legget, had this to say about his professor:[5]

> If the students had had an opportunity to evaluate his teaching capability, it would certainly have been rated good. The format of the lectures was always the same. First, all books were closed. Then the subject matter of the day was thoroughly set out and discussed. Finally, in the last five or 10 minutes, books were opened and concise notes written out on the blackboard. Being able to listen without having to take notes was unique to us and did impress the subject on our minds. And of course, the notes were orderly and complete for later reference, either for exams or after graduation.
>
> Each course included a final handout: Supplement to Lecture Notes and Suggestions for Further Study. These were intended for long-term reference, included discussions of required and recommended reading (articles and books), and tried to motivate us to learn more about the subject by observations and notes, particularly about performance and cost. Authors noted in those days included H.A. Mohr, Juul Hvorslev, D.W. Taylor, D.P.

> Krynine, Jacob Feld, D.M. Burmister, R.R. Proctor, N.M. Newmark, C.A. Hogentogler, and of course Arthur Casagrande and Karl Terzaghi. These are all Americans.[6] Canadians referenced were Dr. A.P. Coleman, Prof. I.F. Morrison, and Drs. D.F. Putnam and L.J. Chapman, among others.
>
> Students, especially in the final year at university, often feel that they can 'relate' to a particular professor more than the others. RFL was such a one in our case. It was very evident from the first that he was interested in us as individuals. He emphasized that his door was always open and welcomed us to talk to him about such decisions as job opportunities. However, this doesn't mean that he was soft on us. He abhorred the idea of "set" examinations—one of our senior profs always made six out of 10 questions on his exams identical year after year, and the pass mark was 60! Legget kept us off balance: one year he had (I think) eight questions on a paper, and the next (to our horror when we first saw it) he posed only one (comprehensive) question.
>
> He was also the only professor who always invited the senior class to his home for an evening each term. We were a bit apprehensive and there was joking about it beforehand, but we saw RFL's more personal side and had some interesting discussions. But his ethics were such that he would never reveal his convictions in either religion or politics, for fear of turning our young minds!

Legget's son, David, recalls these student-professor get-togethers at their home and remembers that it became a tradition for the students to present his father with a set of 78-rpm records of a classical symphony, Legget's favourite genre of music.

When Legget received his Companion of the Order of Canada in 1989, two of his students from the 1940s wrote and congratulated him.[7] One letter said:

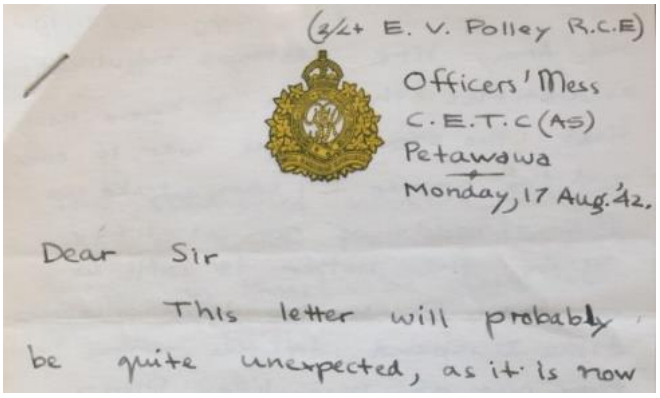
> The course you were teaching was 'Mechanics of Materials' and I probably learned about bending moments and beam design… But I learned a much more important lesson from you. This was something vague that I call 'professionalism'. …I have never forgotten your example of self-discipline, your meticulous appearance, your precise manner, and your ability to state a problem or a proposition in a clear, concise and understandable way. …I want to thank you for the positive influence that you had on my professional development.

The other said:

> I would have to admit that I can now recall virtually nothing of what you taught me … And yet, one thing you told us at that time I have remembered clearly to this day. That was—always remember, an Engineer is also a gentleman. That good advice made a lasting impression on me, and throughout my career I have tried to honour it.

Perhaps the most poignant relationship that Legget had with a student was with Victor Polley. Circumstances had the Irish-born Polley studying civil engineering at U of T at the start of the Second World War. He graduated in June 1942 with honours, then attended officers' training and became a Second Lieutenant in the Royal Canadian Engineers. He went overseas in December 1942.

Prior to his leaving for Europe, Polley wrote Legget a very personal letter on RCE letterhead.


(2/Lt E. V. Polley R.C.E)
Officers' Mess
C.E.T.C (AS)
Petawawa
Monday, 17 Aug. '42.

Dear Sir

This letter will probably be quite unexpected, as it is now

Portion of Page 1 of Victor Polley's letter to Legget (LAC 4-2)

It starts, "This letter will probably be quite unexpected, as it is now so long since you have heard from me." The letter goes on to describe his very personal feelings about the war and the small part that he was playing in it.[8]

He wrote Legget once again before he was killed in a motorcycle accident on active duty somewhere in England in March 1943. Shortly after Polley's death, Legget took the time to type the section of Polly's letter shown in the annotations and add a short biography concluding with:

> Unusually well read, a brilliant student, a keen thinker and a good friend, Lieutenant Polley leaves behind him a lasting impression upon all who knew him. The engineering profession could ill afford to lose one of his calibre.

From the above, it appears that the lasting influence that Legget had on his students was, at least in one instance, a two-way street!

While working on his textbook *Geology and Engineering* in 1938 and 1939, after the textbook was published, and indeed throughout his entire tenure at U of T, Legget continued his tradition of writing. In addition to his numerous anonymous short contributions to the *Engineering News-Record* as its Eastern Canadian Correspondent, between 1938 and 1947, Legget wrote approximately 50 articles and papers. Most were articles for various engineering magazines (*Canadian Engineer, (UK) Civil Engineering, (US) Civil Engineering, (US) Engineering & Contract Record* and *(US) Roads & Bridges*) and general interest magazines (*Queen's Quarterly, Dalhousie Review, Canadian Forum, Saturday Night* and *The Beaver*). Some were papers for engineering journals such as the *Engineering Journal, Journal on Engineering Education, Economic Geology, Journal of the Royal Architectural Institute of Canada, Transactions of the Royal Society of Canada* and *Transactions of the American Society of Mechanical Engineers.* Legget's most frequent topic was still general construction; however, he wrote ten articles and papers associated with geotechnique.[9] He also wrote six articles and papers associated with environmental conservation and two papers associated with housing and city planning, both new areas of interest for him. Most of these publications were listed in the University of Toronto President's annual reports for the period 1939-1946.

In comparison, during the same period, those same annual reports show that C.R. Young, the Department Head and Dean of Engineering, published ten articles and only two other Department of Civil Engineering colleagues published anything—one publication each.

Likely inspired by the success of his 1939 textbook, Legget immediately started to prepare an outline for another textbook, this one tentatively titled *An Introduction to Construction for Civil Engineering Students*. In the mid-1940s, coinciding with his new interest in environmental conservation (see below), he also prepared an outline for a textbook on "conservation of about 40,000 words." As mentioned in Chapter 9, in 1933, Legget started to draft an outline for a textbook on "Power" and, while at U of T, he continued to work on this textbook. None of these subsequent textbook ideas came to fruition.

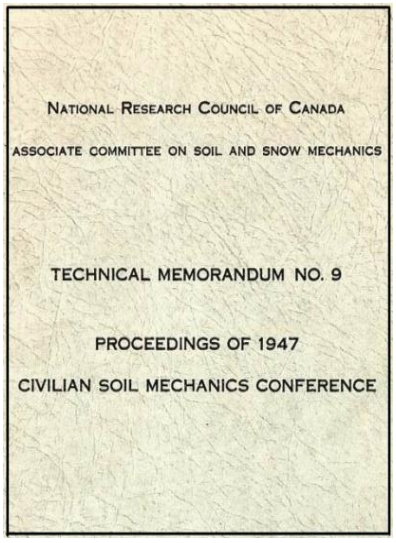
During his U of T years, Legget was a frequent attendee of the Annual Conferences of the Engineering Institute of Canada, held in various cities across Canada. At the 1945 conference in Winnipeg, he co-chaired a two-paper session on "Soil Mechanics." This is considered the first organized conference session on soil mechanics held in Canada.

Legget's involvement with the Shand Dam on the Grand River in 1939 piqued his interest in environmental conservation and led him to the influential 1941 "Guelph Conference"[10] and the Conservation in Eastern Ontario Conference held in Kingston in 1945. Because of his active involvement with the conservation movement in Ontario at that time, Legget is considered by some as one of the leaders of the environmental conservation movement in Ontario, a movement that led to the 1946 *Conservation Authorities Act of Ontario*.

While at U of T, Legget also continued his tradition of joining and participating in professional associations. He became an Associate Member of the (US) Highway Research Board and represented Canada on its Soils Committee. He became a member of the American Society for Testing Materials' Committee D-18 on Soil and Rock.[11] He joined the American Geophysical Union. He was elected a Full Member of the (UK) Institution of Civil Engineers. In 1941, he was elected a Full Member of the Engineering Institute of Canada and joined the Executive of the Toronto Branch the following year, becoming Vice-Chair of that branch in 1946 and 1947.

At the university, Legget served as Chairman of the University Radio Committee for a period of time and, between 1941 and 1943, he was the Chairman of the "Committee Representing the Teaching Staff"—today's faculty association.

In 1945, Legget was appointed the Chairman of the National Research Council's Associate Committee on Snow and Soil Mechanics. In that capacity, in April 1947, he organized and chaired the "Civilian Soil Mechanics Conference," which was to become the first annual Canadian Geotechnical Conference, the longest running annual geotechnical conference in the world.



Cover of the Proceedings of NRC's 1947 Civilian Soil Mechanics Conference

As mentioned previously, in 1939 Legget made inquiries as to what was required to obtain a DEng from the University of Liverpool, but he did not pursue it at that time. In March 1946, he inquired again and this time he did apply. In January 1947, he submitted three copies of his textbook *Geology and Engineering* and two other engineering papers. In May of that year he received a response from the university that stated, "I regret to inform you that the Faculty passed a resolution to the effect that your applications be declined."[12] This must have been quite a blow to Legget and one that was not entirely rectified until 1971 when he was awarded an honorary DEng by the University of Liverpool, one of 13 honorary degrees that he was ultimately awarded.

As will be described in Chapter 14, early in 1947, Legget made the decision to leave U of T and take the position of founding Director of the National Research Council's Division of Building Research in Ottawa. His memoir mentions that the letter that Dean Young sent him upon Legget making his decision to leave U of T "is one of my treasures." In that letter, Young somewhat formally, but with restraint, wrote:[13]

> I cannot but be pleased with your kindly references to myself in connection with our association at the University of Toronto. While under the autonomous department system prevailing in the Faculty, I could not do all that I wished … to make clear publically and privately my great admiration for your abilities and devotion to any obligation that you serve or task that you undertake.
>
> I know full well the real reasons that impelled you to withdraw from the university, but I could discover no immediate way of circumventing them in a manner that would give full scope for your abilities.
>
> Your future with the NRC is bound to be one of notable achievement, but, for all that, it is my belief that you will return to academic life before many years have passed, and under auspices that will give you plenty of latitude.
>
> Very best personal regards to both yourself and Mrs. Legget.

In 1938, Legget had joined U of T as an assistant professor and had been promoted to an associate professor in 1943. It appears that he left the University with a somewhat sour taste in his mouth. With all his documented achievements while at the university, did he think he should have been promoted to professor or department head? The “real reasons that impelled [Legget] to leave the university” are unknown.

Legget may not have been completely happy with his lot at U of T, but he maintained a full schedule while there. This included having heavy teaching loads during a number of sessions, running his soils laboratory, being involved with his students and the university, spending most summers away from home on consulting assignments, writing extensively, involving himself with various associations and attending conferences.

During this period, Legget also spent time with his wife and young son. Successively, they lived in three houses in Toronto: first 244 Glenrose Avenue, then 49 Poplar Plains Crescent and finally 46 Castle Frank Crescent. Son David remembers the Castle Frank residence as a classic old Victorian home with a servants’ staircase and quarters for a butler, neither of whom the Leggets employed.

While living in Toronto, Legget and his family travelled for the first time to Grand Manan Island, NB, for a holiday.[14] Once they found this island retreat, it became their holiday destination for at least a couple of weeks each year for many, many years. In 1980, Legget wrote a paper for the *Canadian Journal of Earth Sciences* on the “Glacial Geology of Grand Manan Island.” In the acknowledgements, he wrote, “This record has been prepared on the basis of observations made during successive summer visits to Grand Manan, annually when duties permitted.” In Legget’s Library and Archives Canada files, there are copies of numerous professional letters he wrote and typed while “holidaying” on the island.

Left: 244 Glenrose Avenue in the Moore Park area (1938-1943) (photo by Doug VanDine 2019). 49 Poplar Plains Crescent in the Summerhill area (1943-1944) (photo source Google Street View 2018).

64 Castle Frank Crescent in the Rosedale Ravine area (1944-1947) (photo source Google Street View 2015)

Grand Manan Island held a special place in Legget's heart and, for many years, he used a wave-washed, sandstone cobble from the southeast portion of the island as a paper weight on his desk in his home study. It is one of the few of his father's keepsakes that his son has kept.

Legget's paper weight from Grand Manan Island; approximately 7.5 cm across (photo source David Legget)

The summer of 1947 ended Legget's eleven years in academia. In spite of the suggestion by Sandy Macphail of Queen's University and the belief of Clarence Young of the University of Toronto, Robert Legget did not return to academic life.

Annotations Chapter 13: UNIVERSITY YEARS IN CANADA (1936-1947)

[1] Queen's University and the University of Toronto calendars of that period provided the addresses of the faculty. See Chapter 24 to see how to access these calendars.

[2] *Saturday Night* was Canada's first general interest magazine and was published between 1887 and 2005 (Wikipedia).

[3] University of Liverpool Archives. At the time in the UK, a DEng could be awarded based on either a suite of submitted publications or the more conventional route of course work, research and a thesis.

[4] From a review of U of T calendars, a summary of the courses Legget taught during his tenure at the university is shown below.

UofT Civil Engineering Course					Session								
No	Name	Level (Yr)	Term(s)	Hrs/week	38-38 (1)	39-40	40-41	41-42 (2)	42-43 (2)	43-44 (2)	44-45 (2)	45-46	46-47
20	Applied Mechanics/Statics	1	1+2	2				●	●	○			
23	Mechanics of Materials	2	1+2	2				●	●	○	○	○	○
24	Engineering Mechanics (3)	2	1+2	2				○					
25	Mechanics of Materials (4)	2	1+2	1				●					
26	Engineering Mechanics (3)	1	1+2	2				○	○				
32	Graphical Methods	3	1+2	1	●	●	●	●					
39	Foundations, Retaining Walls and Dams (5)	4	1+2	1	○	○	●	●	●	●	●	●	●
40	Soil Mechanics	4	1	1				●	●	●	●	●	○
47	Structural Design (4)(6)	5	1+2	4	○	○	○	○	○	○			
50	Mechanics of Materials: Soils and Highways (7)	4	2	3					○	○	○	○	○
315	Contracts and Specifications	4	2	1				●	●	●	●	●	●
316	Management	4	1+2	1	●	●	●	●	●	●	●	●	●
Legget's course load: teaching couse by self (●) + teaching course with others (○)					2+2	2+2	3+1	8+3	6+3	4+4	4+2	4+2	3+3

Notes:
(1) assumed same as 39-40 session
(2) some faculty on war leave 41-42 to 45-46 sessions
(3) taught to Department of Engineering Physics students
(4) taught to School of Architecture students
(5) "Dams" removed from course title in 46-47 session
(6) 1 hr lecture; 3 hrs lab
(7) new course in 42-43 session

[5] This contribution by Lionel Peckover was attached to Legget's May 1983 Supplement to his March 1983 memoir.

[6] These individuals may have been working in the US, but only some were born in the US.

[7] LAC 3-21

[8] Following is a portion of Victor Polly's August 17, 1942 letter (LAC 4-2).

> We have to do more to beat Germany. When Germany is beaten, we shall have to fight battles at home, and in world politics, if this world is to be a place worthy of the bloodshed which will take place. I feel keenly that something must be done to win these battles.
>
> Someone must lead the world into the path of peace and order. The men who must do this are the thinking men—men who have hitherto been content to vote, and otherwise do nothing. These men

> are the engineers, doctors, and all the other professional men in the country. I realize my own responsibility very keenly, and I intend to do everything in my power to help achieve these things, when the war is over. But my effort is useless if others do not think seriously of this problem. If every Engineer and all the thinking people in the country make up their minds, as I have made up mine, to do everything they can (even at the cost of sacrifice) to build a better world, then natural leaders will arise from their ranks to carry these things into the realm of reality. Even an active fearless engineering society or association, conscious of its responsibility to the people, could do a lot to improve conditions. They have the power, the latent power, and if they use that power to the last unit in doing something for the betterment of this world, then they are only fulfilling their moral duty to mankind.
>
> This is not the talk of a young college student grasping at new ideas. These are the things I know to be right, to be my duty. I don't think about them all the time, I realize their truth and acceptance. Unfortunately I do not think the majority of engineers have given much deep thought to the subject.

[9] A listing of Legget's publications associated with geotechnique is in Chapter 23.

[10] At the conference held in Guelph, ON, conservationists from across Ontario met to discuss the extensive damage to southern Ontario's environment as a result of poor land, water and forestry practices that led to extensive soil loss and flooding (Wikipedia).

[11] Legget's association with the ASTM would culminate with him becoming the President in 1965 and 1966.

[12] LAC 1-26

[13] LAC 3-10

[14] Grand Manan, NB, located just north of the Canada/US border, is the largest island in the Bay of Fundy.

[Chapter 14:] OTTAWA (1947 AND ON)

Building Research must have come first to my attention through meeting *[Leonard]* Cooling at the 1936 Conference.[1] The Building Research Station (of Great Britain) was then well established[2] and continued as the only national building research organisation in the world until 1946-47 i.e. after the Second World War. I must have seen pre-war references to "BRS" and also to Dr. Stradling (later Sir Reginald)[3] but I did not know (naturally) that he had paid two pre-war visits to Canada to discuss with General *[Andrew]* McNaughton, then President of the National Research Council,[4] the possibility of Canada aiding the BRS with its cold weather work! Preparation of the first National Building Code of Canada, started in 1939, naturally drew attention to problems in building that needed investigation but, although the Code was finished (in 1941),[5] the war naturally clouded all such extraneous possibilities.

Accordingly when, in the spring of 1946, I was called upon in connection with snow research to make an official visit to Switzerland,[6] travelling by way of London, Dr. *[C.J.]* Mackenzie, the Acting President of NRC,[7] knowing of the contacts I had in England, asked me to look into the "building research situation" in Great Britain with special reference to their post-war plans and to report to him on my return. This I did, being introduced to Sir Reginald Stradling by one of my former lecturers at the University of Liverpool, *[then]* one of his chief aides.

Sir Reginald gave me a wonderful over-view of the history and future of building research in the UK. On the basis of this, and other information which I was able to pick up in my few days in London, I was able to prepare a Report for Dr. Mackenzie within a few weeks of my return to Canada.

[Mackenzie] told me later that, deliberately, he did not read it before he himself went on a visit to the United Kingdom when he made his own inquiries. When he did read my report, on his return, he was good enough to tell me that he was grateful for it, since it saved him from writing a report of his own; his conclusions being the same as mine. Essentially these were that the twenty-one years' experience of BRS[8] had proved the value of building research beyond doubt; that all such research must be carried out in the closest liaison with the construction industry and design professions; that with the prospective post-war "building boom" in Canada even then being envisaged, some sort of research in the building field was desirable for Canada; and that, if the National Building Code was to be kept up to date, then building research must somehow be started here.

Later that year (1946) a large meeting was convened in Ottawa, under the auspices of the Department of Reconstruction (I think) to discuss the specific research needs of post-war housing in Canada, then already seen to be a matter of high priority. I was invited and was an interested observer of the jockeying for position on the part of representatives of interested

agencies (especially the Mines Branch and the Forest Products Laboratories[9]). I kept quiet, especially when the discussion got round to the idea of an inter-departmental committee on housing research since, even then, I had seen some of the difficulties of actually doing research under the aegis of a committee. In all this, never once did the very idea of my having anything to do with building research in Canada cross my mind; I was far too interested (as can be imagined) at the possibilities I could see opening up for Soil Mechanics (Geotechnical) research at the University of Toronto.

A little time after this meeting, I was in Ottawa again on Associate Committee *[on Soil and Snow Mechanics]* work. After I had made my regular report to Dr. Mackenzie on the progress of the track research,[10] he surprised me by asking what I thought of the housing research meeting and the conclusion of the meeting. I indicated my reservations about the idea of a committee, no matter how good; he agreed and told me that he had already taken to the *[National Research]* Council the concept of setting up a new Division of Building Research within the NRC organisation. Later he told me the idea had been approved by Mr. *[C.D.]* Howe,[11] who was then engaged in setting up Central Mortgage and Housing Corporation[12] and who saw that a Research organisation for buildings within NRC would be a fitting complement. (Being the man he was, C.D. Howe knew instinctively that you can not really do research within an operating organisation such as the CMHC; others in Ottawa had to make this discovery the hard way.) When the Council had made its decision, then Dr. Mackenzie asked me to help him to find the right man to be the first Director.

I have to smile when I think of the names we discussed so privately and so frankly. I was, however, completely unprepared for what happened on 7 January 1947 when "C.J." got up from his desk, walked to the window (I can see him now) turned round and said "Legget, we're wasting our time; you should be the Director." Never having dreamed of this, I gave him, off the top of my head, all the reasons I could then think of as to why I should not be this pioneer, one being that I was anxious to get on with geotechnical research. "That's part of building research," was his answer to that! He told me to go away and think about it which I did, with my wife; it was an agonizing decision to have to reach but after several weeks we decided to accept.

Dean *[C.R.]* Young (as he then was[13]) was most understanding; the letter he sent as I left *[the University of Toronto]* is one of my treasures.[14] But leaving the University, our friends and the lovely house we had in Rosedale[15] was not easy. It was done, however, in rather hectic weeks and, after a short holiday in the United Kingdom (when I spent a day at BRS and my long and close friendship with their new Director Dr. Lea, now Sir Frederick,[16] was firmly established), I reported for duty at the Sussex Drive building of the Council[17] on Monday 1 August 1947.

Those who have managed to read this far will probably think that it is just another of "Legget's tall stories" when I state that, within two hours of entering the doors of NRC, I was handed the first enquiry to DBR/NRC and it was a geotechnical problem! It was a foundation

problem at Chalk River and I had to go up there about it within a day or two,[18] so I had my "baptism of fire"...and it never stopped.

Inquiries soon were coming in at an increasing rate, once the existence of the Division was known, eventually to the extent of several thousand every year. (The Division used to get more mail than all the other Council Divisions and activities at the Montreal Road laboratories.[19]) I mention this for a good reason. If it *[had]* not been possible to "sit back and think" a bit about the course to be charted, I would have been sunk in a mass of paper. So in the course of the first year, after visiting all the interested organisations in Canada and the USA and starting what proved to be most happy liaisons, a plan of action was hammered out, with Dr. Mackenzie "looking over my shoulder"; he never interfered but, at first, I reported to him about once a week, while he gradually pushed me off on my own.

Through knowing Fred Lea *[of the BRS],* and following an early visit to Ottawa by the newly appointed Director of *[Building Research Institute]* for South Africa, as well as a visit of mine to Washington where the National Bureau of Standards started their Division of *[Building Research]*[20] in the same month as did Canada, it became very clear that Building Research, to be fully effective, had to be developed internationally. This was done, through regular, five-yearly meetings of the "Directors of Building Research in the English-speaking" world (all personal friends) and, on the broader canvas, through CIB (le Conseil International du Bâtiment).[21] Even today, I think that it can still be said (as it certainly could in my day) that no branch of applied research is so truly international in coverage, and integrated activity, than is building research.

This looks like growing into a history of DBR/NRC: not so! The foregoing explanation, however, is necessary to explain why it was that, in hammering out the overall policy for DBR, it was possible to concentrate upon only those branches of work that must be done in Canada, leaving to other countries problems which, although relevant to Canada, could better be done elsewhere, e.g. problems of buildings in hot climates, whereas all agreed that Canada must take on building problems of cold climates. This resulted in a policy of having six major branches of activity *[in the DBR]*.

[These were] Foundations and Soils (since you can't study Canadian soils in South Africa), Snow and Ice (under Dr. Mackenzie's urging, since no research in this vital field was then even contemplated elsewhere in Canada), and Building problems of the North (the North of Canada being one of this country's unique responsibilities)...all geotechnical, and not because of my own personal interests! The other three?: Fire research (Canada's fire record being a national disgrace), the whole matter of building materials in our climate, and an over-riding concern for the enclosure of space, again in the Canadian climate (and this included housing research, roofs, insulation etc....the sort of things that come first to mind when building research is mentioned). In all these fields, the objective was the same—to deal with immediate problems and, by developing expertise in these fields, to act as a catalyst in getting *[research]* work started elsewhere in Canada, especially at Universities.

The work of DBR/NRC has, fortunately, been written up, supplementing its own long list of publications, starting with *Ten Years of Building Research.*[22] (We "had no time" before 1957 to contemplate putting together such a record.) Accordingly, in this record it is necessary for me only to touch upon some of the more personal aspects of each of the four main branches of Geotechnique as they were tackled in the Division.

[Muskeg]

Muskeg received the least attention, in view of the extensive programme of Dr. Radforth, first at McMaster University and then *[the University of New Brunswick]*, but Ivan MacFarlane was the one research officer who, in the (old) Soil Mechanics section *[of the DBR]* did excellent work on muskeg and produced some often-cited publications before he went on to other work.[23]

[Snow and Ice]

Snow and ice research was slow in starting, really requiring the cold-room facilities of the *[Building Research]* Centre (opened in 1953) before laboratory work could commence.[24] But the visit, for one year, of Dr. *[Marcel]* de Quervain of Switzerland,[25] as a guest worker with DBR, produced a masterly report on what Canada should be doing in these fields that is still, in a way, the "Bible" for this important activity.[A] C.D. Pearce was the first research officer *[in the DBR's Snow and Ice Section]*, followed by L.W. Gold,[26] now the Associate Director of the Division.

[Northern Research]

Very shortly after I arrived in Ottawa, I met Dr. O.M. Solandt, then Chairman of the newly formed Defence Research Board (an offshoot from NRC in the post-war reorganization). We hit it off and so had a number of useful talks about our respective spheres of action and immediate plans. The North of Canada naturally came into our talks even though "Exercise Muskox" was then the only National Defence northern activity (I think),[27] and there had been practically no civilian activity other than the normal work of the RCMP and Hudson's Bay Company, and the few small mines down the Mackenzie *[River]*. We both agreed that, taking the long view, this was an area that must be looked into and Dr. Solandt encouraged me to get busy on finding out what we could about building in the North and especially about permafrost, the word then just coming into use to describe the perennially frozen condition of the ground in the North. That was the start of the still-continuing northern programme of DBR, this in 1947.

[A] de Quervain, M.R. 1950. *Snow and Ice Problems in Canada and the USA,* NRC/DBR Technical Report No 5, 69 p.

In my hunt for staff, I was lucky enough to come across John Pihlainen, a Finnish-Canadian civil engineering graduate of McGill who had spent two summers in Labrador (I think) and so had got the "Northern bug", a reflection possibly of his own Finnish background.[28] He joined the Division in 1949, and by the summer of 1950 it proved possible to organise an expedition, jointly with *[the Department of National Defence]*, down the Mackenzie River to the Arctic coast for a study of every building in the Mackenzie Valley in order to determine what were the special building problems of the North. The result was a useful report, jokingly known within DBR as "The Doomsday Book of the North".[B]

That was the beginning of permafrost research in Canada, now often forgotten by new workers in the field. A small field station was established in 1952 at Norman Wells, NWT, using ramshackle left-overs from the Cano1 project.[29] A well-built station followed, being officially opened in 1956 by Dr. E.R. Steacie, President of the *[National Research]* Council,[30] during the course of the first tour of the North ever made by members of the Council. The opening ceremony was highlighted by one of the best of the many humorous stories that developed in the early history of the DBR.[31]

[Soil Mechanics]

I have left the start of Soil Mechanics research to the last since it was allied, through the people involved, with the Associate Committee *[on Soil and Snow Mechanics]*. On the staff of the *[NRC]* Division of Mechanical Engineering, when I arrived in August 1947, was F.L. Peckover who had been a student *[of mine]* at the University of Toronto.[32] I think (but F.L.P. can check me on this) that Mr. J.H. Parkin, Director of the Division of Mechanical Engineering, had some idea of starting soil mechanics research in his Division before it was known that DBR was to be established. There was no difficulty in having "Peck" transferred to the staff of the new Division of which he therefore became the first Research Officer. Mr. Parkin kindly made space available for the start of a soil mechanics laboratory in his Hydraulics Building[33] and here the first laboratory of the Division *[of Building Research]* was established by early 1948.

The winter of 1947-48 was one of the most severe Ottawa has ever had and so we were called upon for help by the City Waterworks Engineer. It was also the first winter during which snow had been cleared from city streets and so there was much trouble with frozen pipes, leading us into a study of soil temperatures, at that time almost a virgin field for research. The first published research paper of the Division was one written jointly by F.L.P. and R.F.L. which was presented to the 29th meeting of the (US) Highway Research Board on "Soil temperature

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[B] Pihlainen, J.A. 1951. *Building Foundations on Permafrost,* DBR Technical Paper No 8, DBR No 22, 42 p.

studies", the beginning of what is now a long series of notable research papers in the field of Soil Mechanics.[C]

By a strange coincidence, I had called on Dr. John Paterson, Head of Canada's Weather Service, in Toronto, on 20 February 1945, since I had seen by then that soil temperature studies would be vital in Northern research. *[Canada's Weather Service]* had some very early records.

After getting the soil mechanics lab well set up and the section well organised, and following notable service as the first Secretary of the Associate Committee, F.L.P. felt the need for actual experience in the field and so, by mutual consent, left the Division in order to accept the position (to my delight) of Chief Soils Engineer on the construction of the St. Lawrence Seaway. His work here was notable and he published a splendid paper summarising this experience before joining Canadian National Railways, where he served until his early retirement.[34] He was succeeded as head of the Division's Soil Mechanics section by Carl B. Crawford, now the Director of the Division,[35] the record of whose fine work is well documented in DBR reports. I know that *[Crawford]* would join with me in this brief tribute to Peckover's pioneer work as one of the very earliest Canadian workers in the geotechnical research field.

Finally a very brief personal note, since here is where I really bowed out of active participation in geotechnical research. When I was appointed, Dr. Mackenzie got me to promise him that, despite all the claims that administering the new Division would make on me, I would never let a day go by without at least brief contact with my main personal interest, geotechnical research; he had seen "too many" Directors lose all touch with active research. I kept my promise, although with great difficulty in those early hectic months, my "contact" being merely keeping in touch with what literature there then was.[36] I looked forward to doing at least a little experimental work when the Division was organised, staff recruited and the Building Research Centre[37] in full use. So in the planning of the building, I asked the Architect to include a small laboratory bench with sink in the small working office for me which he included in his plans just off the Board Room, the Director's "official office".

We moved into the building on schedule; in due course the organisation of the Division was developed but the pressures got worse (if possible) and so continued until my retirement *[in 1969]*. I think I used the little lab bench for one experiment! The bench was used mainly for holding some of the piles of "paper" which had to be dealt with. And so reluctantly, I had to accept the fact that my research days were over, apart from keeping in as close touch as possible with the work that Carl Crawford and his colleagues were doing, occasionally joining in as a joint author, but only when I had had some definite part in the work being reported, generally in discussion of ideas or in more general field studies.

[C] Legget, R.F and Peckover, F.L. 1949. "Soil Temperature Studies—a Progress Report," *Proceedings Highway Research Board*, 29th Meeting, Washington, DC, pp 434-445.

The research achievements of the Division were all the work of others, work which gave me increasing delight as I watched over it and did my best to get the necessary support. And chairmanship of the Associate Committee *[on Soil and Snow Mechanics]* kept me in touch with the broader field. To the story of the committee we must return.

Annotations Chapter 14: OTTAWA (1947 AND ON)

[1] As mentioned in the annotations in Chapter 8, Leonard Cooling was Head of the Soil Mechanics Section of the UK Building Research Station and Legget first met him at the 1936 International Conference.

[2] The British Building Research Station was established in 1921 as a government funded laboratory to conduct research for the Building Research Board and thereby help improve the quality of housing in the UK. It is now known as the Building Research Establishment and was privatized in 1997 (Building Research Establishment website).

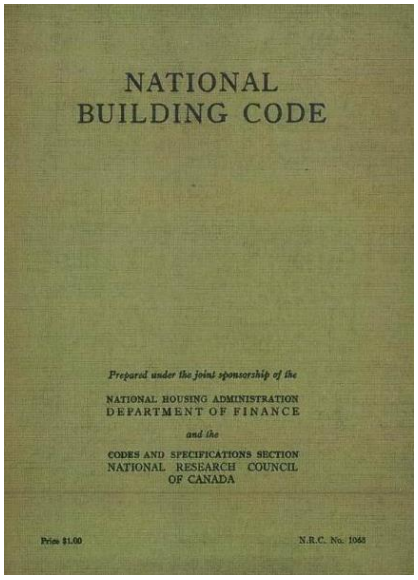
[3] Reginald Stradling (1891-1952) was trained as a civil engineer at Bristol University. He worked as a consultant and in academia until 1924 when he was appointed Director of the UK Building Research Station. He was knighted in 1945. He stepped down as Director in 1946. In 1949, Stradling was appointed Dean of the (UK) Military College of Science, now the Royal Military College of Science (GracesGuide website).

[4] The National Research Council of Canada (NRC) was formed in 1916 to advise the government on both military and civilian scientific and industrial research. It became a more formal government body in 1928. In 1932, the NRC research laboratories were opened at 100 Sussex Drive in Ottawa. During the Second World War, much of its research was of a military nature.

General Andrew McNaughton served as President of the NRC between 1935 and 1944, although C.J. Mackenzie served as Acting President during much of the war (Wikipedia).

Andrew McNaughton (1887-1966) was born in Saskatchewan (then part of the Northwest Territories) and was a 1910 electrical engineering graduate of McGill University. He had distinguished military careers during both the First and Second world wars (Wikipedia).

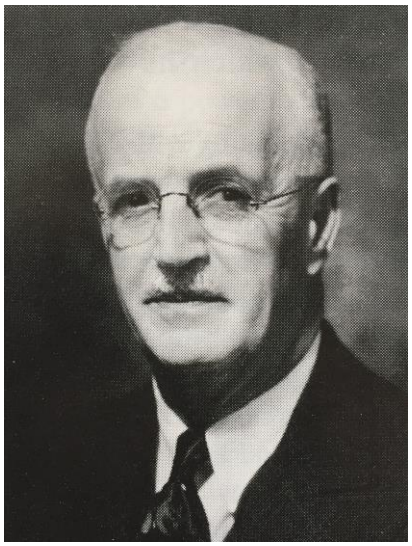
[5] Prior to the National Building Code, the responsibility for building regulations belonged to the provinces and territories and this responsibility was typically delegated to municipalities. Because each municipality tried to deal with its own needs and issues, these regulations often varied from one municipality to the next. This situation frequently made it very difficult for architects, designers, engineers, product manufacturers and contractors, as well as for national programs that supported construction. In the late 1930s, to help alleviate the difficulties associated with the multitude of municipal building regulations across the country, the federal Department of Finance asked the NRC to develop a building code that could be adopted by all municipalities in Canada. The result was the first edition of the *National Building Code of Canada*, published in 1941.



First Edition of the *National Building Code [of Canada]* 1941

[6] Legget will say more about his trip to Switzerland in Chapter 15.

[7] C.J. Mackenzie was introduced in the annotations in Chapter 4. He became President of the NRC in 1944. Therefore, Legget's reference to Mackenzie being Acting President in 1946 is incorrect.



C.J. Mackenzie (photo source University of Saskatchewan Archives)

[8] This should read "twenty-five years", the BRS being established in 1921.

[9] In 1946, the Mines Branch was a branch of the federal Department of Mines and Resources, and is currently a branch of the Natural Resources Canada.

The Canadian Forest Products Laboratories were established in Montreal in 1913, in co-operation with McGill University, as a part of the Forest Service of what was then the federal Department of the Interior. The research is now carried out at three locations: the main laboratory in Ottawa (established 1927), the Vancouver Laboratory in Vancouver (1918) and the Pulp and Paper Research Institute of Canada, which is still in Montreal (Food and Agriculture Organization of the UN website).

[10] As explained later in Legget's memoir, "track research" was the first area of research to which the Associate Committee turned its attention.

[11] This was the same C.D. Howe who was the Minister of the federal Department of Reconstruction and Supply.

[12] The Central Mortgage and Housing Corporation was created by the federal government in 1946 to help house returning war veterans. Until 1979 known as Central Mortgage and Housing, its current mandate is to help Canadians access a variety of affordable housing options. It also provides housing and real estate trend research to consumers, businesses and government (CMHC website).

[13] As mentioned in Chapter 13, C.R. Young was the University of Toronto Civil Engineering Department Head (Municipal and Structural) from 1929 to 1945 and the Dean of Applied Science and Engineering from 1941 to 1949.

[14] A copy of this letter is in Legget's files in the Library and Archives Canada (LAC 3-10) and is quoted in Chapter 13.

[15] The Toronto residence to which Legget refers is 64 Castle Frank Crescent. Refer to Chapter 13.

[16] Frederick Lea (1900-1984) was the Director of the British Building Research Station from 1946 to 1965.

[17] The photo below, taken in 1945, shows the NRC laboratories at 100 Sussex Drive in Ottawa, which were opened in 1932.

The NRC laboratories at 100 Sussex Drive in Ottawa in 1945 (NRC Archives)

[18] It is not known what "foundation problem" Legget was investigating in Chalk River; however, it was likely related to the NRC's Chalk River nuclear research laboratory, located on the Ottawa River, approximately 200 km northwest of Ottawa.

Initially established by the British and Canadian governments in Montreal in 1942, the Chalk River facility was opened in 1944. In September 1945, this facility became the first nuclear reactor outside the US. The following year, the NRC closed its Montreal facility and focused on its Chalk River facility. Atomic Energy of Canada Limited (AECL) was formed in 1952, with C.J. Mackenzie as president, and took over the facility from the NRC. The Chalk River reactor was shut down in 2018 and is currently awaiting decommissioning (Wikipedia).

Chalk River nuclear research facilities in 1945 (photo source Wikipedia)

[19] The Montreal Road laboratories of the NRC are located on an approximately 50-hectare site that straddles Montreal Road, approximately 6 km east of the original NRC laboratories at 100 Sussex Drive, in Ottawa. The area was part of the former RCAF Station Rockcliffe. The first of the Montreal Road laboratories was constructed in the late 1930s. The area is now known as the Montreal Road Campus. (NRC Archives).

[20] The US Division of Building Research is now the Building and Fire Research Laboratory of the (US) National Institute of Standards and Technology, administered by the US Department of Commerce (US Department of Commerce website).

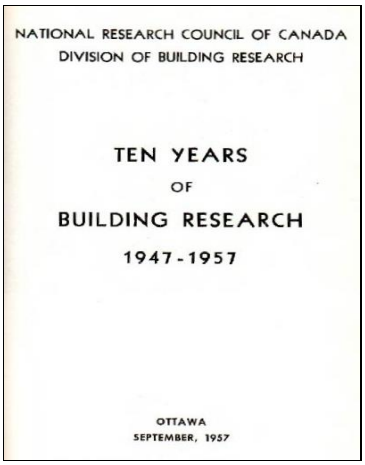
[21] Conseil International du Bâtiment, or more correctly Conseil international du bâtiment (CIB):

> …was established in 1953 as an association whose objectives were to stimulate and facilitate international cooperation and information exchange between governmental research institutes in the building and construction sector, with an emphasis on those institutes engaged in technical fields of research.

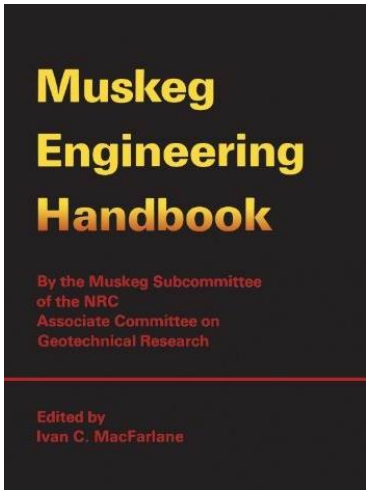
> The CIB has since developed into a world-wide network of over 5,000 experts from about 500 member organisations with a research, university, industry or government background, who collectively are active in all aspects of research and innovation for building and construction.

In 1998, the name was changed to International Council for Research and Innovation in Building and Construction, but the acronym, CIB, has stayed the same (CIB website).

[22] The 120-page *Ten Years of Building Research, 1947-1957* was published by the NRC/DBR. This publication started a series of annual or bi-annual reports on Canadian Building Research.



[23] Ivan Coleman MacFarlane (1929-2018) started working at the NRC/DBR in 1954 and continued working there until he retired in 1989. Among the many other publications he contributed to, MacFarlane edited *Muskeg Engineering Handbook*, a 297-page textbook published by the University of Toronto Press in 1969. For many years it was the standard Canadian reference on the topic.



[24] The cold-room facilities were constructed as part of the Building Research Centre, as one of the NRC's Montreal Road laboratories. See later annotation.

[25] Marcel R. de Quervain (1915-2007; Encyclopedia Britannica website) came to Canada as a guest of the NRC/DBR for one year. The main purpose of his visit in the late 1940s was to examine the problems of snow and ice in relation to the Canadian economy. D.C. Pearce, then Head of the Snow and Ice Section, accompanied de Quervain on his visits to snow and ice research institutions in Canada and the US, including an ice reconnaissance flight in 1949 "which revealed most strikingly the extent of the ice cover on Hudson Bay". They covered approximately 24,000 km in two and a half months (NRC/DBR Technical Report 5, 1950).

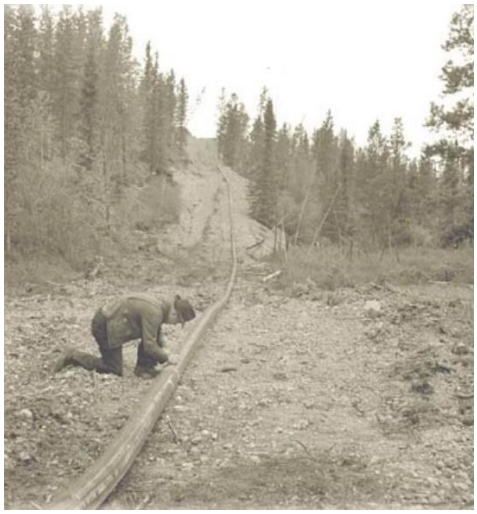
[26] Lorne Gold (1928-2018) joined the NRC/DBR in 1950 shortly after graduating from the University of Saskatchewan. He retired from the same organization in 1986. Gold pioneered ice and snow studies applied to ice pressures on dams and bridge piers. In 1969, after serving as Head of the Snow and Ice Section for many years, he became Head of the Geotechnical Section and in 1974 became Assistant Director, and then Associate Director of the Division of Building Research (CGS website; Lives Lived).

[27] Legget says more about “Exercise Muskox” in Chapter 15.

[28] John Pihlainen (1925-1964) pioneered the NRC/DBR’s investigations of permafrost and associated construction problems. He left the DBR in 1960 and established his own consulting practice. Pihlainen died suddenly of a heart attack in his 38th year (CGS website; Lives Lived).

[29] Norman Wells, NWT, (population 809 in 2017) is located along the Mackenzie River at latitude 65° N. It is approximately 1,500 km north of Edmonton and 145 km south of the Arctic Circle. The explorer Alexander Mackenzie noted oil along the river when he passed by the area in 1789. The oil-bearing formation was discovered in 1911, Imperial Oil started drilling in 1919 and built a small refinery that operated until 1925. Imperial Oil started to develop the area and the town in earnest in 1937 and a much larger refinery was completed in 1939. This refinery was closed in 1996, but the area still produces approximately 120,000 barrels of crude oil per year which is transported to Edmonton by an Enbridge pipeline, completed in 1985. (Wikipedia and Canadian Encyclopedia online)

During the Second World War, the approximately 950 km Canol (short for Canadian Oil) Road and associated 10 cm diameter oil pipelines were constructed by the US Army to move crude oil from Norman Wells to Whitehorse, YT, and then to Alaskan tidewater. Oil started flowing in late 1943 but was stopped shortly after the war. The 355-km Canol Heritage Trail is all that remains of the Canol Road in the NWT. In the Yukon there is a 449-km stretch of the road, some of which can be driven. Both sections are now a part of the Trans-Canada (Great) Trail (Wikipedia).



The 10 cm diameter Canol Pipeline (photo source Wikipedia)

[30] Edgar William Richard Steacie (1900-1962) was a physical chemist who joined NRC’s Chemistry Division in 1939 and became NRC President in 1952, succeeding C.J. Mackenzie. Stacie died while president. The Natural Sciences and Engineering Research Council of Canada annually awards up to six EWR Steacie Memorial Fellowships to young Canadian scientists (Wikipedia).

[31] The humorous story is that the refrigerator in the brand new NRC Norman Wells Station, although reputed to hold permafrost, when opened during the opening ceremonies, was full of home-made beer (CGS website; Lives Lived, John Pihlainen).

[32] F. Lionel (“Peck”) Peckover (1921-2015) graduated as a civil engineer from the University of Toronto in 1944. According to a note he prepared in 1983, he took seven courses from Legget while at university: Statics; Strength of Materials; Highway Engineering; Soil Mechanics; Foundations, Dams and Retaining

Walls; Contracts and Specifications; and Management. Legget has more to say about “Peck” later in this chapter.

[33]The Hydraulics Building was constructed as part of the Montreal Road laboratories in 1942. According to *War History of Division of Mechanical Engineering, National Research Council of Canada,* published in 1946, “Besides the laboratory space mentioned above, the [Hydraulics and Fire Hazard Laboratory] building houses four offices, drafting room and space for a soil mechanics laboratory” (NRC Publications Archive website). Therefore, Legget was correct in remembering that J.H. Parkin was thinking of starting soil mechanics research in the NRC’s Division of Mechanical Engineering.

[34] While Peckover was working with the NRC/DBR, Legget encouraged him to pursue graduate studies in geotechnical engineering under the supervision of Arthur Casagrande at Harvard University. Peckover graduated from Harvard in 1947 and returned to the DBR where he worked closely with Legget until 1953. He then worked as the Chief Soils Engineer of the St. Lawrence Seaway Authority from 1953-1959. After that he joined Canadian National Railways and became its Engineer of Geotechnical Services from coast-to-coast. Many consider Lionel Peckover to be the “Father of Geotechnical Engineering for Canadian Railways.” Upon retiring from the CNR in 1976, he joined Canac Consulting, where he carried out studies for a proposed high-speed rail line from Montreal to Windsor. Peckover fully retired in 1984 (CGS website; Lives Lived).

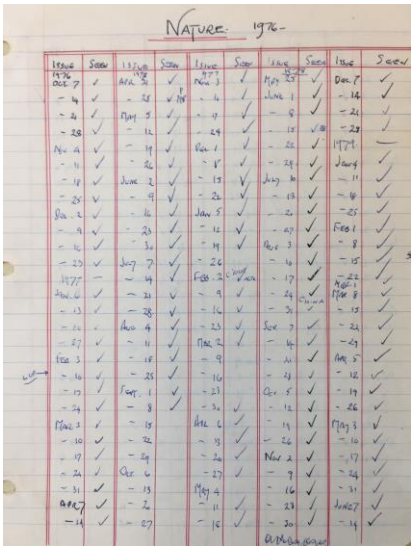
[35] Carl Benson Crawford (1923-2010) graduated as a civil engineer from Queen’s University in Kingston in 1949, followed by postgraduate degrees from Northwestern University in Illinois and Imperial College in London. While a student at Queen’s, Crawford attended a lecture by Legget and was so impressed that he decided to join the DBR’s Soil Mechanics Section, becoming its head in 1953. He became Director of the Division of Building Research in 1974, a position he held until his retirement in 1985. Crawford was the recipient of the 6th CGS R.F. Legget Award in 1975.

After his retirement, Crawford continued to pursue his research interests at Cambridge University (England), the Norwegian Geotechnical Institute (Oslo), the Centre for Cold Oceans Research (St. John’s, NL) and the University of British Columbia (Vancouver, BC) (CGS website; Lives Lived).

In retirement, Crawford also compiled all the “Historical Notes” that Legget prepared for the *Canadian Consulting Engineer*. See Chapter 23.

[36] Legget was a voracious reader. In his files in the Library and Archives Canada, there are records of him reading or reviewing: *The Engineering-News Record, Engineering & Contract Record, Canadian Engineer, Engineer Journal, (UK) Civil Engineering, (US) Civil Engineering, New Civil Engineer, Transactions/Proceedings of the American Society for Civil Engineers, Transactions of the Canadian Society of Civil Engineer, Canadian Geotechnical Journal, Canadian Journal of Earth Sciences, Economic Geology, Engineering Geology, Nature, Science, New Scientist, Scientific American, American Journal of Science,* and *Transactions of the Royal Society of Canada* (LAC 20-4).

In the same files, there is evidence of Legget keeping a record of which issues of which journals he had reviewed. The following photo is of Legget’s record with respect to *Nature,* the internationally acclaimed British scientific journal, first published in 1869.



Legget's record of which issues of *Nature* for 1976 he reviewed (LAC 20-4)

[37] Construction of the Building Research Centre began in 1951 and the building opened on October 23, 1953.

Legget is second from the left. Although not obvious, the words "Building Research" are worked into the metal artwork at the top of the glass above the entrance way. (photo source NRC Archives)

Legget and C.D. Howe at the opening ceremonies. (photo source NRC Archives) The plaque reads:

National Research Council Division of Building Research
This Building Research Centre
was dedicated to serve the research needs
of building throughout Canada
by
The Right Honourable C.D. Howe, M.P., B.Sc.
Chairman of the Committee of the Privy Council on Scientific & Industrial Research
on the 23rd day of October 1953
J.C. Meadowcroft, F.R.A.I.C, Architect, Montreal
Robertson Construction and Engineering Co. Ltd.
Contractor, Niagara Falls.

[Chapter 15:] THE ASSOCIATE COMMITTEE

The Associate Committee on Soil and Snow Mechanics (now *[the Associate Committee on]* Geotechnical Research)[1] was established on 20 April 1945. On that day the first meeting of the newly formed group was held in the Sussex Drive Building of the National Research Council. It was a short meeting (two hours) but it launched the Committee on its urgent wartime task[2] with an indication that, in due course, it would be transformed into an "ordinary" Associate Committee for the purpose indicated by its name. There is, in the office of the Committee of today, a complete set of Minutes of meetings of the Committee, and of its publications, which may therefore be consulted for any gaps that may have to be filled.[3]

It seems desirable that I should try to record the things about the Committee, such as its initiation, that are not in the Minutes. Again, I regret that I did not have enough sense to keep a good record of these developments at the time but from my work diary, aided by a reasonable memory, I believe the following to be a "true and correct record." (F.L. Peckover will be able to check at least parts of it.[4])

I was much too close to the operation of the Committee to be able to assess its full impact on the Geotechnical scene in Canada, but I believe that it was a helpful influence. Dr. N.B. Hutcheon watched the work of the Committee from "the outside;" he is a mechanical engineer and was Assistant Director of *[Division of Building Research]* throughout most of the period of the Committee's peacetime work (under my Chairmanship).[5] Somewhere he wrote an appreciation of the Committee which would be a helpful part of this record since it was by an independent observer unconnected with Geotechnical work; if I can locate it, I will add it to the memoir as Appendix.[6] Accordingly, what now follows is a factual record of the initiation of the Committee with some notes on its work etc. to supplement the official Minutes of its proceedings. After that, I will include some general notes about Associate Committees, in the light of our early experience with the one now under review.

We must start at the beginning of the year 1944, a time that can only be described by that over-worked word "hectic"—the days were that indeed. The Allied forces had landed in France on 6 June 1944 (D-Day) and had made such fine progress that many thought that the war in Europe would be over by the end of that year. This did not happen, the German counter-offensive starting in the Ardennes on 16 December lead to some of the most bitter fighting of the war.[7] Canada was fully geared up to its maximum war effort, overseas and here in Canada; the demands of war dominated everything but there was hope in the air as the tide of war could be seen finally to be turning, in Europe and in the Far East.

Normal annual functions still took place, but on a muted scale, and so the annual meeting of the Engineering Institute of Canada (then a really great engineering meeting, sometimes attended by more than a thousand) was held in Winnipeg on 9-10 February (1945). One session

was devoted to papers on some aspects of Soil Mechanics; I believe that this was the first such *[soil mechanics]* meeting ever held in Canada. Joint chairmen were Prof. A.E. Macdonald (of the University of Manitoba)[8] and me. The two papers were by Bob Peterson and Gerry Williams on the use of Soil Mechanics by *[the Prairie Farm Rehabilitation Administration]* and the Manitoba Department of Highways, *[respectively]*.[9] They aroused much interest and good discussion, both at the meeting and privately long into the evening. This must have been my first *[conference]* meeting with Bob P. and Gerry W., but I had met them previously. I think that Bob Hardy was at the meeting. And I am under the impression that either one or both of the papers were later published in the *Engineering Journal*, in which case they will be two more of the pioneer papers.[10]

Dr. C.J. Mackenzie (President NRC) was then a past President of the Institute and so he was at Winnipeg. When I got back to Toronto, after a visit to Steep Rock following Winnipeg,[11] I found a message asking me to telephone him, in Ottawa. This I did, and he asked me to prepare for him a brief review of the "state of the art" in Soil Mechanics, without explaining what this was for; this was on Monday 19 February 1945. I sent a draft of this statement (of which I now regret I have no copy) the next day. When I heard from C.J.M. in reply, he asked me to come up to Ottawa as soon as I could; this I did on Saturday 3 March. I saw Dr. D.C. Rose (a senior scientist in the Division of Physics *[of NRC]*)[12] who explained to me, in the greatest confidence, the problem that had arisen with tracked vehicles, about which we had a good talk. During the morning I saw Dr. Mackenzie also, but I have no record of my talk with him; later, I saw Professor R.E. Jamison[13] and Colonel G.M. Letson[14] (of whom more later).

On 12 April 1945 *[US]* President Roosevelt died.[15] The shock of this news went all round the free world; those of us who can remember it will recall it as one of the things we shall never forget. The media had covered up his serious illness and so we were all unprepared for the news. Nothing had appeared in print, or almost nothing, about his Vice President, and so successor.[16]

I was in Hart House, at the University of Toronto, just coming out from a dinner when a man, coming the other way, told me. It was as if "the end of the world had come" since Roosevelt and *[British Prime Minister Winston]* Churchill had, between them, built up an image of confident fortitude that was a sort of life-line in the days of bad war news. We gathered in small groups, all else being forgotten, to discuss this dreaded event, and what was now to happen. Someone thought that the Vice President was some miserable little ex-haberdasher from Missouri, a machine politician, whom "nobody" had ever heard of, and so worry and uncertainty about the future deepened. How utterly wrong we were, although it was a year or more before we began to find out! It was Roosevelt who had been the weak man, in his final decline in health, and President Truman gradually showed himself in his true colours, one of the strongest and greatest Presidents that the United States has ever had.

This may sound like a diversion, couched in unusual language for me—but what I say reflects the general feeling at the time, and this event had a profound effect upon the early work of the Associate Committee. After a day or two the shock of the news began to wear off, and

everyone buckled down to wartime work again with a will, the more urgent since nobody knew what would now happen; our confidence in President Truman was a long way in the future. And so, when I was asked to go to Ottawa again, to get started on the tracked vehicles study, it was a welcome call to action.

I went up on the night train, on 19 April 1945, and was soon at the Sussex Drive building of NRC to preside, at Dr. Mackenzie's insistence, as Chairman of the new Committee. In addition to Dr. Mackenzie himself, who sat through the whole meeting, and me, there were Colonel John Tuzo Wilson,[17] then Director of Operational Research for the Canadian Army; Colonel G.M. Letson, the Director of Engineering Development for the Army and Professor R.E. Jamieson of McGill University, on loan to the Departments of Munitions and Supply as Director of Engineering Services, and from the National Research Council, Dr. D.C. Rose of the Division of Physics; George Klein[18] from Mechanical Engineering (because of his work on snow in connection with aircraft skis) and F.L. Peckover[19] of the same Division to serve as Secretary. The meeting lasted two hours; a little later, I joined Dr. Mackenzie for lunch at the Rideau Club[20] and heard in more detail what he had told the Committee, being given my "marching orders" in his own inimitable low-key style, with promise of his full support.

In summary, Dr. Mackenzie explained to us that, when the Allied Forces went into France with the best assembly of military vehicles that the world had probably ever seen, their only real difficulty was that many of these splendid engines of war bogged down in the "mud" of northern France. This was never admitted or even mentioned in wartime news-reports, but he told us that it was so serious a problem that at the very top policy level (to which he was always Canada's senior adviser) it had been agreed that it was a problem that must be solved, since nobody knew when the war would end, or what new turns it might take, Hitler now acting like a mad-man. The British were to concentrate on operational research, to find out just what did go wrong; the United States, in the tradition of the automobile industry (in which research means building a full scale prototype and trying it out), were already embarked upon full scale testing, having taken over two agricultural experimental stations which had long test bins for trying out machinery.

Canada had no such facilities as these and so it had apparently been agreed that we should look at the theory of operation of tracked vehicles, to see if this would suggest desirable improvements—in other words, as Dr. Mackenzie put it, we were to use our brains, as Canada had already done in other wartime fields. I hesitate to use that word "brains" in this most personal narrative so let me hasten to add that my job was to find the brains, mobilise them and guide them in the work to be done. The Army would try to get the best possible personnel; Dr. Mackenzie had already arranged for an initial budget of $15,000;[21] we would have *[access]* to all US and British work, and were urged to maintain liaison with them, especially the US; and if, as our work developed, I wanted for anything, I was just to ask for it.

Finally, Dr. Mackenzie explained that the steering committee had to have a name, and a name which would be a complete camouflage since, at first, the work was classified (I think) as

Top Secret. He therefore suggested—and this was entirely his own idea—that we should call ourselves the Associate Committee on Soil and Snow Mechanics.[22] The word snow was there since there was already quite serious talk of a winter invasion of Norway (how strange that idea now sounds!) in which Canada would have a leading role to play. Over lunch, C.J. explained to me the operation of *[other NRC]* Associate Committees, and showed me by examples how successful they had been.

[Mackenzie] had been following, despite all the claims of war upon him, developments in Soil Mechanics and had been impressed by the proceedings of the Winnipeg EIC meeting, and so he was certain that, when peace came, Canada must have a medium for supporting the development of Soil Mechanics in peacetime use. And also snow mechanics, something nobody had then ever heard of but, possibly because of his many years as Dean of Engineering at the University of Saskatchewan, he knew that snow must be studied in exactly the same way as soil. This, then, was the beginning and so, as will be seen, the real founder of "organised soil mechanics in Canada" (if it may be so expressed) was Dr. C.J. Mackenzie.

Happily he was able to follow, always with close interest, the steady development of Geotechnique in Canada. He gave me the inestimable gift of his friendship, more particularly after my retirement in 1969, and so in our well-nigh weekly talks, I told him of significant advances in Canadian work, always reporting fully on the annual conferences. He even came, when in his mid-eighties, to the lamentable disastrous twenty-fifth anniversary dinner, staying right to the end of that awful evening.[23] He is still alive as I write this, but now not well, although we had our usual talks until mid-1982.[24]

Despite all the challenges ahead, I had to go back to Toronto, to get ready for the special "extension" course already arranged for and booked solid.[25] As already noted *[in Chapter 12]* this went well, but as soon as it was over, and after conducting business in the meantime, generally by telephone, I was back in Ottawa again, soon becoming a "commuter."[26] I had managed to spend four days up there at the very end of April, having useful discussions with some of those who were going to help, notably Colonel Wilson, visiting the Vehicle Proving Grounds at Orleans,[27] and the Soil Service of the Dept. of Agriculture, since even then I could see the value of a link between Soil Mechanics and its work. This gave me my initial meeting with Alf Leahey,[28] who was at first surprised by this first approach from anyone outside agricultural soils work, but who welcomed the overture and became a tower of strength in mutual developments.

"V/E Day" was on Tuesday, 8 May. Reading this today, one might think that all need for the new committee automatically disappeared but this was not the case at all. There was still the fighting in the Far East ("V/J Day" coming on 2 September[29]). Even after that, the loss of President Roosevelt still being an influence, there was such uncertainty and distrust of the Soviet Union that warlike activity continued generally through 1946. Armies were demobilised and there was much conversion of wartime facilities to peacetime use but the continuance of what

may best be called the "armed truce" is, perhaps, best typified by the fact that the United States conducted its first atomic bomb tests (in the Pacific) in June 1946.[30]

The work of the Associate Committee therefore continued unabated. Before it began to be transformed into the Associate Committee we know today, the concept of the "spaced-link track,"[31] based on our research work had been developed, so the original job was done. How best to summarise those busy days?

I think it will be desirable for me to concentrate first on the Committee as such; by listing its meetings, the tempo of its work will be well reflected. The meetings of the Associate Committee were, therefore:

1st 20 April 1945
2nd 15 June 1945
3rd 24 August 1945
4th 29 September 1945
5th 7 December 1945 (in Toronto; five *[meetings]* in seven months)
6th 9 February 1946 (in Montreal)
7th 16 March 1946
8th 30 May 1946
9th 5 September 1946 (four *[meetings]* in twelve months)
10th 29 March 1947
11th 16 September 1947
12th 11 December 1947 (three *[meetings]* in twelve months)

...and thereafter what became a normal pattern of two meetings (generally) each year.

Dr. Mackenzie only attended one meeting after the first but he kept in close touch with the Committee and its work through my reports to him, and the written records he had time to examine. Don Rose dropped out after that first meeting, having done the job that the President (whose special assistant he was) had asked him to do. But the other participants (Wilson, Letson, Jamieson, Klein and Peckover) were most faithful attendants, only very rarely missing a meeting.

They were a fine team to work with. It may be worth recording (and I think F.L.P. will be able to confirm this) that the early meetings of the Committee were a splendid example of the well-known fact that a well-chosen small committee can achieve very much more than would be achieved by the summation of individual contributions of its members, acting separately, no matter how good they may be. Once we started to discuss the track problem, Tuzo Wilson's brilliant mind would be in full action, ideas coming out just like sparks off an emery wheel; Bert Jamieson would sit there, smoking his pipe but saying nothing until he sensed an idea had merit when the pipe would be laid down and he would say quietly, "I think we should discuss that"; Colonel Letson, the perfect military man, always precise, quiet in speech, keeping our feet on the ground and never letting us forget that it was an urgent <u>military</u> problem that we were discussing; George Klein, with his quite phenomenal one-track mind, listening carefully, making the odd

comment, but the leader as soon as we got on to snow. Peck and myself? We were just the Secretary and Chairman.

Colonel Wilson stayed on the Committee even after he gave up his military position to become a member of the teaching staff of the University of Toronto (as will shortly be related). Colonel Letson stayed active until he, too, left the Army and returned to his home in Vancouver, after the seventh meeting. Bert Jamieson went back to McGill at about the same time, his place from his Department *[of Munitions and Supply]* being taken by N.C. Millman (on loan from General Motors, Oshawa) who continued the liaison as long as the Department of Munitions and Supply existed. Bert Jamieson, however, remained on the Committee, so interested was he in its work and future potential, retiring only in June 1952. Peckover passed the Secretaryship on to Don Nazzer,[32] also of the Division of Mechanical Engineering, NRC, after the eighth meeting, while he took a year's study leave for a graduate course in Soil Mechanics at Harvard University; he rejoined the Committee as Secretary in late 1947.

The first Army officer assigned to the Committee was a Captain "Jake" Kastner but for reasons which I do not now recall, he did not stay long, being replaced by Captain M.G. Bekker of the Royal Canadian Engineers;[33] he came, first, to the fourth meeting. Indicative of the continuing "pressure" on the Committee was the welcome presence at the fifth meeting (December 1945) of the Master General of the Ordnance of the Canadian Army, General McQueen, and his Deputy, Brigadier Morrison, who came to be briefed personally on what we were up to!

This meeting was held in Toronto, at the University, so that the Committee and the visitors could see the research work being done, in my laboratory in the Electrical Building, on the track problem; photographs of one of the experiments accompanied the Minutes of the meeting. To spread the load a bit, a Subcommittee on Track Studies was set up but did not become too active even though interest in track studies continued into 1949. Major Bekker then got an appointment at the Stevens Institute of Technology (New Jersey) and so faded from the scene. (For any who wish a more detailed account than this, there is a useful history of the early days of the Committee as an Appendix to the Minutes of the 18th meeting, held on 21 April 1951).

The transition from the wartime committee to the Associate Committee as it is today was not a sudden change; it was rather, and to general agreement, a gradual shift in emphasis. Dr. Mackenzie made quite clear that this was what he wished. As early as the fourth meeting, I find that I mentioned the idea of sub-committees to be responsible for each branch of Geotechnique when the Committee was able to turn its attention to peacetime tasks. At its seventh meeting (March 1946) the Committee approved the preparation of a report on Soil Studies in Canada required for a forthcoming Commonwealth Scientific Conference in London, but directed that this should be submitted through the National Research Council and by the Department of Agriculture, as had been suggested, an interesting indication of the ignorance, even at that time, of engineering soil studies.

The first significant change was at the fifth meeting (in December 1945) when Dr. Norman McLeod[34] joined the Committee as the first representative (so to speak, but not officially) of civilian Soil Mechanics. He was then on leave from Imperial Oil Ltd. to the Department of Transport, engaged on his notable work on airport runway design. He contributed much to the Committee, being eventually succeeded by John Walter of the Ontario Department of Highways, another pioneer worker.

Dr. N.W. Radforth[35] first came to a meeting of the Committee (the tenth) in March 1947, as a guest, although the Committee had been supporting his muskeg research financially. At this same meeting, the Committee approved of the holding of the first Soil Mechanics conference, to which later reference will be made. Dr. P.O. Ripley[36] came to the 13th meeting (in March 1949), the beginning of the long-continuing and valued link between the Committee and pedological soil studies in Canada. Minutes of the 18th meeting (27 April 1951) were the first to be issued with no classification attached to them, clear indication that the Associate Committee had fully assumed its peacetime role.[37]

This role had already so increased the workload of the Committee and its Secretary that Miss Margaret Gerrard was engaged, in 1948, by the Division of Building Research to serve as Assistant Secretary to Mr. Peckover, but the work of the Division was expanding rapidly and so, at the 21st meeting (in March 1953), Mr. W.J. *[Bill]* Eden[38] took office, as Secretary giving devoted service until he in turn retired *[as Secretary]* in 1967; he now serves the Committee as its Technical Advisor.

Mr. Peckover left for his work on the St. Lawrence Seaway. Miss Gerard left her position in order to take charge of the Publication programme of DBR/NRC, to what good effect is now widely known. She was succeeded by Miss Gloria Zuana (1952-57) as Assistant Secretary; *[Miss Zuana]* then took on other duties in the Division and is now a member of the staff of the Canada Council. Mrs. Audrey Roper followed Miss Zuana (1957-59) but after a short period she was appointed as the Director's Secretary, a position she occupied under successive Directors until her own retirement in June 1982, a fact which can be left to speak for itself. (The Director of DBR/NRC had to persuade the Chairman of ACSSM to let Mrs. Roper leave.[39]) Miss Joy Butler then started her long service with the Committee (1959 to the present) first as Assistant Secretary with Mr. Eden and then, from 1967, as Secretary of the Committee, having been Mrs. Joy Curran since 1971.

I wish to record my special appreciation of what these early (and in the case of W.J. Eden and Joy Curran, continuing) workers have contributed to the Committee since it has been upon the basis of their work that the Committee was able to advance as it did. When my own three-year terms of office came up for renewal, I "made noises" in appropriate quarters about being relieved of this pleasant but demanding task. There was always evidenced such strong feeling within and outside the NRC that, since I was also the Director of DBR, this was a link for the Committee through its Chairman that was too valuable to be lost. And so my protests were

"shot down in flames" until 1967 when I held the ace of spades,[40] if I may mix my metaphors, and was able to pass on the Chairmanship, with pleasure and confidence, to Carl Crawford.[41]

Here I can stop and leave any more details of the Committee that may be needed for others to relate. I should, however, add brief notes about each of the civilian branches of work to which the Committee turned, and their initiation, as well as about the track studies.

Track Studies

This should have been one of the highlights of the "Committee story" but, through a most strange development, it did not turn out that way. Memory being the wonderful phenomenon that it is, I have long since forced myself to forget much of the unpleasant part of this story, while up to this point memories have been almost always crystal clear. Nothing is now to be gained by going into the matter in any detail and so I will give the most concise summary possible of what was one of the happiest research experiences I have ever had, spoiled only in its closing phase.

The Canadian Army managed to find, as successor to Capt. Kastner, a Captain M.G. Bekker to work with me on the track problem. Bekker was a Polish military engineer who had had a remarkable escape from Poland at the start of the war, finishing up in Ottawa. He had worked, in Poland, on military vehicle design and was very bright; so he was a "natural" for this job. We hit it off immediately and became close friends, our families also. He started with desk-top experiments in a glass-sided sand box to see just what did happen under loaded grousers.[42] This proved so rewarding that the Committee authorised us to build a proper lab set-up in the Soil Laboratory at UofT, properly instrumented; we were given, for a time, the services of Lieutenants Hamblin and Belford (two former civil *[engineering]* students of mine at UofT).[43]

While experimental work continued, Bekker and I worked on the theoretical explanation. Looking back, it was not too difficult a problem; nobody had thought before us (apparently) of investigating the failure of soil under the combined horizontal and vertical loading upon a grouser. Theory agreed with experiment, and so ultimately we were able to predict what the resistance to a grouser would be. When two or more grousers were used (as in a real track) it was easy to see that there was a critical spacing between grousers which should be observed if the action under one grouser was not to interfere with the resistance of the adjacent one. So arose the concept of the "spaced-link track."[44] All experiments were initially in sand but eventually Bob Peterson (of PFRA) was asked to ship to Toronto a good block sample of really sticky gumbo clay. Here memory fails me; I have no recollection of experiments in clay, but some may have been done. Reports were made regularly to the Committee; the *[Committee]* acted as a most helpful advisory group.

Results were recorded in the following Technical Memoranda issued by the Associate Committee, copies of which were distributed, without delay, to British and US authorities - so the work was known in appropriate quarters:[45]

TM #1 *Proposed Field Soil Testing Device* – August 1945
TM #2 *Ground Failure Under the Action of a Track Grouser* – September 1945
TM #3 *The Interrelation of Soil Mechanics and the Design and Operation of Vehicles* – November 1945
TM #4 *Soil Survey of Vehicle Proving Establishment, Ottawa* – October 1945
TM #5 *Method of Measuring the Significant Characteristics of a Snow-Cover*, (NRC Report No MM 192) – November 1946
TM #6 *Fundamentals of Soil Action Under Vehicles (Part One)* by Robert F. Legget and M.G. Bekker – November 1946
TM #7 *Preliminary Notes on 'Muskeg' from Churchill* by Norman W. Radforth – March 1947
TM #8 *Fundamentals of Soil Action Under Vehicles (Part Two)* by M.G. Bekker, Directorate of Vehicle Development, Department of National Defence – June 1947

TM #6 was the vital document. Bekker and I wished that we could have published the contents of it; it might have been useful.[46]

All these were naturally classified before publication. Despite all efforts, long after the imperative of war made the classification understandable, the Committee was unable to get them de-classified, the most extreme example of bureaucratic inertia I have ever experienced.[47] Finally, the Committee got fed up and at its 14th meeting (14 October 1948) they instructed me to prepare, jointly with Bekker, a "civilian paper" on the work, for presentation to the Society of Automotive Engineers for its next annual meeting.[48]

Bekker had been spending a lot of time in the United States, first (I think} with General Motors, then at the Aberdeen Proving Ground.[49] So, in concert with him by correspondence, and with his complete agreement, I prepared the joint paper (really a civilian version of TM #6) and submitted this to SAE with a copy to Bekker. After he got his copy, he sent a telegram to NRC (whether to Dr. Mackenzie or me, I don't remember; I think to C.J.M.) saying that he would take legal action against the Council if the paper was presented (and/or published) with my name on it since his professional integrity was affected etc. etc. I had not previously encountered the "Polish persecution complex"; all concerned agreed that this was an extreme example. I was (naturally) so annoyed that I sent a telegram to SAE withdrawing the paper entirely. It was a joint contribution from NRC and *[the federal Department of National Defence]* and so I should not have done this without consulting DND. And so I was given a polite official reprimand, but by a gentleman with such a delightful twinkle in his eye (and voice!) that I knew that I had taken the action that all concerned (except Bekker) approved of fully.[50]

I do not think that I have had any communication with Bekker since that time. He was soon permanently in the USA but how he got out of his obligation to the Canadian Army, I do

not know. He took the view that all further work was mechanical engineering, with soil mechanics aspects of the problem solved. He went on to gain a reputation in this field, through his books. I know of these but have never looked at them; friends have told me that there is no acknowledgment of the NRC contribution. I was so busy with the development of DBR that I never bothered to follow up the matter; possibly I should have done so, but the days were too short![51]

And so the "Track Studies" have remained yet another minor Canadian research contribution to the wartime effort of Canada, probably unrecorded and so unknown.

Snow Studies

These were recognised from the very start of the work of the Committee, if only because of the notable work done by George Klein (*[Division of Mechanical Engineering]*/NRC) on snow in relation to aircraft skis. He designed the "Snow Kit" which the Committee sponsored, and of which quite a number were distributed for studying the quality of snow in a quantitative way. Apart from Klein's work, we were really in the dark.

Somehow I heard that there was work going on in Switzerland. Through contacts in the Canadian Meteorological Service, I heard that the head of the Swiss Meteorological Services was to be in Canada in late 1945. I went to Montreal to meet him and found Dr. Lugeon a charming man, interested and anxious to help.[52] He told me of the Laboratory at the top of the Weissfluhjoch[53] (mainly meteorological) and of the Swiss Institute for Snow and Avalanche Research at Davos, urging me to visit both. Such was the urgency then attached to snow studies that the Committee told me to arrange the earliest possible visit, with Bekker, adding that I should go in uniform since I would be one of the first Canadian visitors to post-war Switzerland.[54] This was done, and Bekker and I spent a memorable visit in April 1946, being received by the Chief of the Swiss Defence staff at Davos, where we were shown all the Swiss Army's Snow equipment and, at the Institute, their laboratory work, meeting their Chief Scientist, Dr. Marcel de Quervain.[55] There is a summary account as an Appendix to the Minutes of the ninth meeting of the Committee (5 Sept. 1946).

Meantime, the Canadian Army, under Col. *[Tuzo]* Wilson's inspired leadership, had organised Exercise Musk Ox for the early spring of 1946.[56] The leader in the field was Lt. Col. P.D. (Pat) Baird, known to the Committee. Colonel Wilson kept the Committee informed of progress, even to the extent of having one of the progress telegrams delivered to him during the 7th meeting on 16 March 1946!

A later military exercise in the North was Flight Cariberg in which a North Star, a four-engined plane, flew over Arctic Canada for the first time. This was a well-planned exercise, the only landing fields being at Churchill, Fort St. John and Goose Bay, but despite this the whole of

the land area of the North was safely traversed, and most useful observations made on snow coverage and on ice conditions in Hudson Bay.[A] [57]

I had come back from the Swiss trip, during which I also met in London General Seligman, founder of what is now the International Glaciological Society and author of the first real book on Snow (*Snow Structure and Ski Fields*).[58] *[I was]* quite inspired as to what Canada should be doing in this field. But there were no laboratory facilities to speak of, and so active research work had to await the completion of the Building Research Centre in Ottawa *[in 1953]*.

Colonel Wilson had left the Army in 1947 to take up a full Professorship (of Geophysics) at the University of Toronto. Almost at the same time another Associate Committee was organised, under Wilson's chairmanship—on Geodesy and Geophysics. Wilson and I were therefore able to team up, being by this time close friends, with the result that we agreed to establish a sub-committee on Snow and Ice under the joint sponsorship of the two Associate Committees.

There is an amusing Appendix to the Minutes of the 11th meeting of ACSSM, showing by means of a complex chart all the "Snow and Ice" bodies of which we knew, and the relation of the joint sub-committee to them. I had to smile when I looked at this again—a perfect example of how not to do things, as J.T.W. and I soon found out and acknowledged (jointly!) at the 14th meeting of ACSSM on 14 October 1948; thereafter, snow research was under aegis of "our" Associate Committee.

One thing that was done, however, by the two Associate Committees was the holding of a two-day conference (in Ottawa) on Snow and Ice Research in Canada (on 17-18 Sept, 1947), one of the most interesting and useful gatherings that I can now recall from those interesting days. It was enlivened and assisted by the presence of Sir Charles Wright, one of the few surviving members of the Scott Antarctic Expedition of 1910,[59] and joint author of the famous book on *Glaciology* (Wright and Priestley).[60] Sir Charles, a resident of British Columbia in his final years, was active in research until well into his eighties. He was a regular visitor to DBR and followed with lively interest the development of the Division's Snow and Ice Research work, when eventually and initially under D.C. Pearce, but generally under L.W. Gold, it did get started.

Muskeg Studies

Muskeg was also recognised early in the history of the Associate Committee as a special responsibility of Canadian geotechnical research. None of us knew very much about it so the first action taken was the carrying out of a small military exercise by DND, under the personal command of Colonel Letson, around northwestern Quebec and northeastern Ontario, to see

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[A] Legget, R.F. 1950. "Flight Cariberg," *The Beaver*, Vol 281, September 1950, pp 30-34.

what muskeg really was. I can recall so well Colonel Letson reporting, rather sadly, that everybody with whom they spoke in the northern parts of the two provinces had a separate and quite individual explanation of muskeg!

Somehow that triggered my memory and I reca11ed Dr. Radforth and his interest in "palaeovegetography" (Radforth's word).[61] He came as a guest to the next Committee meeting, and so started on his notable work in muskeg research, the record of which others will be able to prepare. I hope that some of the "Radforth stories" will be used to enliven the record; they are legion and delightful, especially the one about his journey to the Falkland Islands, today so topical.[62] I must include one here since N.W.R. and I are the only ones who know it.

The first research grant made by the Associate Committee was to Dr. Radforth, to help him get started with his work. This financial support was continued year by year, supplemented by further grants from the Defence Research Board when it was formed (at the request of NRC) to take over from the *[National Research]* Council all its continuing defence research responsibilities.[63] The Committee got very brief reports of progress but finally, and naturally, asked about publications. With the natural reaction of the "pure scientist" (as he then was), N.W.R. explained that there were some things he just had to investigate before he could venture into publication. This continued; the patience of the Committee was finally exhausted. As Chairman, I was deputed to tell N.W.R. that he would get no more funding until the Committee and the DRB had his first publication paper.

I thought that the best way of doing this was in an informal atmosphere and so, one evening after dinner at my home, Bill *[Radforth]* and I had a nice quiet talk. I told him, in effect, "Not one red cent more until his first paper was on my desk." I wish that I had had a tape recorder! A valued friendship was in danger of shipwreck—but finally Bill saw that I was serious and, very reluctantly, he agreed to but work aside and prepare his first muskeg paper. This was for submission to the Engineering Institute of Canada for its annual meeting in Vancouver (I think).[64] Being N.W.R. he lived up to his word; the paper one day came to my desk and was submitted; I reported this to the Committee; funding was renewed; and that was (as he himself admits) the turning point in his career.

Within a year, he had a major contribution in *Nature* and his work was soon known internationally.[65] It was a matter of special pleasure to me when Radforth's work was supplemented by the work of Ivan MacFarlane, in DBR/NRC, on the more practical end, as already noted.[66] *[Radforth]* soon had some valuable publications, which I still see referenced, before he went on to other duties.

Permafrost Studies

Problems with permafrost (the name just then coming into use to designate perennially frozen ground**)** were mentioned early in the Committee's deliberations but it was not until the

eighth meeting (30 May 1946) that a formal report on the matter was made, and then by Colonel Wilson. At the tenth meeting (29 March 1947) Pat Baird *[of Exercise Musk Ox]* mentioned a study group that had been set up within DND to look into these problems. Then came the establishment of *[the Defence Research Board]* and my discussions with Dr. *[O.M.]* Solandt (Chairman DRB) when we agreed that, since permafrost would be of greatest significance in civilian developments in the North, *[the Division of Building Research]* should be responsible. Later a subcommittee on permafrost was established under the initial chairmanship of Captain (later Major) Scott Lynn *[Royal Canadian Engineers]*, a happy linking of the two interests.

The valuable work of this sub-group of the Associate Committee formed a helpful parallel with the actual field and laboratory research work of the Division, to which it served as a useful advisory group...as did the corresponding subcommittees on Snow and Ice, and Muskeg, as I should have made clear. The National Conferences which each of the subcommittees organised were excellent examples of the effective work of Associate Committees in general.

Soil Mechanics Studies

What, in this context, I can call "Civilian Soil Mechanics" were implicit even in the main wartime task of track studies. We applied to the grouser problem what we could find from then existing knowledge in the field. In the visits which Bekker and I (and, I think, Peckover on at least one occasion) paid to all interested US installations and offices, concerned with track studies, we picked up miscellaneous information about current Soil Mechanics developments.

All of this helped to demonstrate the need for a Canadian forum on the subject and the first move in this direction was the membership of Norman McLeod on the *[Associate]* Committee. Prior to this, however, a Mobile Soil Mechanics laboratory had been developed at the Committee's request, by the Army, for use in a soil survey of the Vehicle Proving Grounds at Orleans, east of Ottawa. It was crude but must have been one of the first of such mobile labs to be used. When the Survey was done, the Lab was left at the Proving Ground and I do not know what its ultimate disposition was—this because there was no civilian agency to which it could be passed on.[67]

At the tenth meeting of the Committee (29 March 1947), it was reported that L.F. Cooling of the British Building Research Station, accompanied by Dr. G.G. Meyerhof[68] (also then of BRS) were to pay a visit to North America. The Committee jumped at the opportunity that this visit would provide and authorised the holding of a two-day meeting in Ottawa, with the visitors, to which all known workers in Soil Mechanics in Canada were to be invited. The Conference was duly held, on 28 and 29 April 1947, and it proved to be the first of the now regular Canadian Soil Mechanics Conferences.[69]

We did not realise at the time what a pioneering venture this was to prove to be since, apparently, it was the first such national Soil Mechanics gathering anywhere *[in the world]*. It has

been a special p1easure to follow the development of these annual meetings, all but one of which I was able to attend. Due, I think, to absence in Europe on building research matters, I could not attend the second Conference held in Lethbridge, a location chosen (I think) so that a field trip could conveniently be arranged to some PFRA projects.[70] Others will be able to take up the story from there on; we saw to it that a good record of each Conference was published.[71]

Associate Committee; Operations

As I have reviewed the records of the Associate Committee, I have seen that there are a few notes on "Operations", supplementary to the minutes, that may be useful. The first relates to the special efforts made, from the start of the peacetime activity of the Committee, to make the Committee itself truly inter-disciplinary. Mention has already been made of the ready cooperation of soil scientists from the agricultural field. Membership was so arranged that there was always one pedologist on the Committee; I recall, appreciatively, the help of Drs. P.O. Ripley and Alf Leahey. Correspondingly, there was always at least one geologist on the Committee, this with the hearty support of Dr. J.M. Harrison when *[he was]* Director of the Geological Survey of Canada, and his immediate successors.[72] This was, to me, always one of the most satisfactory aspects of the Committee's work. To us, it seemed a perfectly natural and sensible way to operate but we soon found out that other countries looked at this Canadian practice with some envy.

[Research Grants]

Younger readers of this note will be surprised to know that the first Research Grants in Canada for geotechnical research were made by the Associate Committee. The first application came at the fifth meeting (7 December 1945) from a certain Dr. R.M. Hardy,[73] requesting support for a study of foundations in Edmonton. Sympathetic as was the Committee, there was then available no money for such purposes, so the request was passed to Mr. J. Lorne Gray, then executive assistant to Dr. Mackenzie. By the 13th meeting (March 1948) there was a little money available to support Dr. Hardy in attending the second International Soil Mechanics Conference,[74] and Pat Baird *[in attending]* a Snow and Ice meeting in Oslo. This resulted from the first research grant, made at the tenth meeting (March 1947) to Dr. Radforth, for his muskeg research.

After the establishment of DBR/NRC, my new colleagues and I, in our journeys throughout Canada, tried to encourage a start at geotechnical research at Universities, seemingly with little success. Money for research grants was always available, amounting to $20,000 out of a Committee budget of $30,000 by 1959.

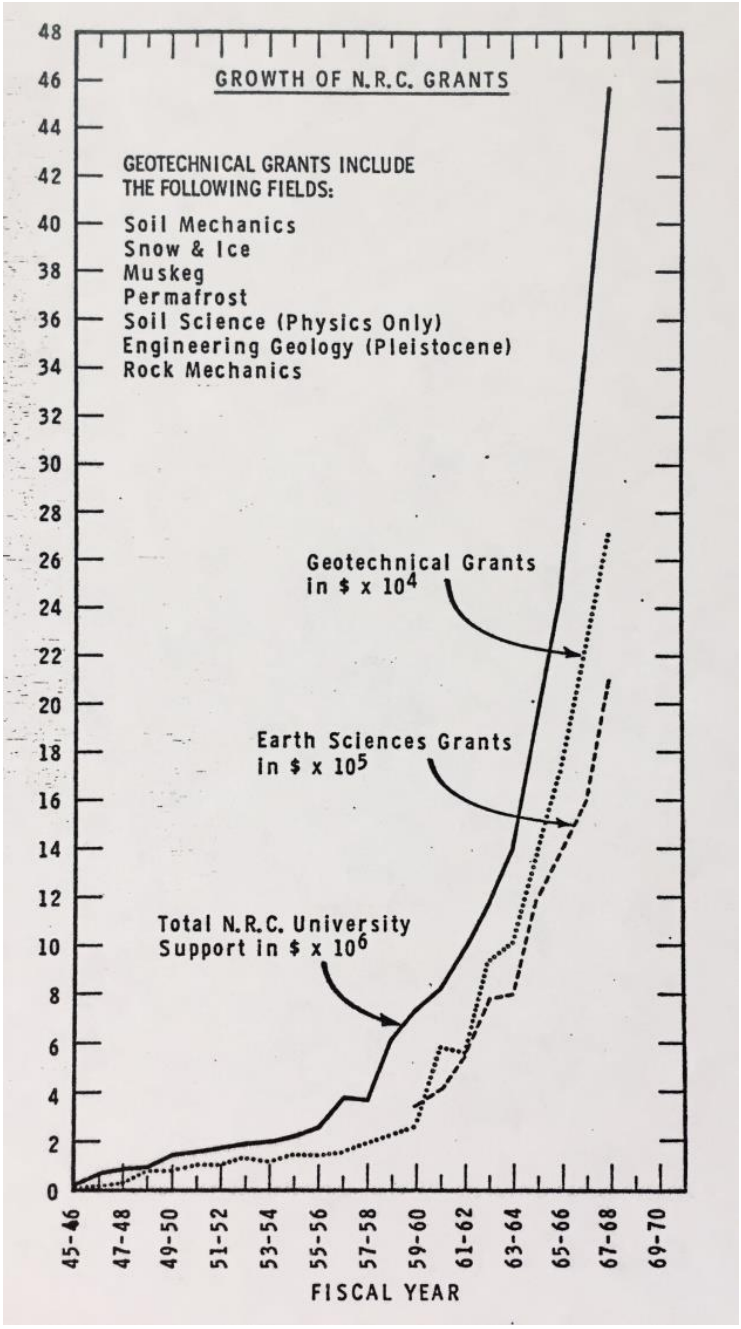
In that year, applications exceeded the money available for the first time, and so I had to approach Dr. Steacie (then President of NRC) about getting some more money. That

precipitated one of my interesting "confrontations" with my revered Chief, conducted in his own inimitable way, but the upshot was that thereafter no Associate Committee was ever allowed to make grants, all being handled by the Council's Grants Committee. Up to that time, these had been restricted to the fields of Chemistry, Physics and Biology (possibly a few in Medicine, but I am not sure).

The real "break-through" (a term I use rarely; here it is correct) was the establishment, by order of Dr. Steacie, of an Earth Sciences Grants Committee, with Dr. D.C. Rose and I as joint convenors. The name was carefully chosen to include all of Geotechnique (as we now know it) and Geology. The Geological Survey of Canada had been making very small grants for geological field research, also just starting in Canada. Dr. J.M. Harrison and I discussed the whole picture (we did many things together) and when we put the broader concept to Dr. Steacie, he supported it fully. And after that, "applied science" was finally given full recognition in the NRC Grants programme. The result is best shown in the following chart *(next page)* which I prepared. All the early missionary work began to pay off. It could well be that the initiation of the research grants programme was one of the most important things that the Associate Committee did—but that is for others to judge.

It was an application for a research grant from Queen's University that was the start of the second of the three (only) jarring notes in this record. Again, memory mercifully refuses to recall all the details, even the year in which this application was received! Fortunately, therefore, I can not give any details or names.

The application was a very strangely worded one for work in the field of Rock Mechanics, so strange that it was decided that I had better go to Queen's and see the applicant. This I did, having one of the very few distasteful interviews that I have had the misfortune to hold. I was told, in no uncertain terms, that rock mechanics had nothing to do with soil mechanics; that "Terzaghi doesn't know what he is talking about" when discussing rock mechanics (and those exact words I do recall); and a lot more along the same lines. I got precisely nowhere.



This record of the start of research grants for geotechnical work in Canada is taken from "Geotechnique and National Development." contained in *Earth Sciences in Canada: A Centennial Appraisal and Forecast*, edited by E.R.W. Neale, Special Publication No 11 of the Royal Society of Canada, 1968, pp 186-202, the volume being another useful source of information.

I was not too surprised, therefore, when the gentleman in question moved on to another University shortly after our talk...but that was the start of the separatist Rock Mechanics Committee (under the auspices of whatever the "Department of Mines" was then called[75]), a development that caused widespread regret but which had to be accepted. (The divorce of soil and rock mechanics is found in other countries also, stemming from the similar international situation—and always due to people). Overtures were made from time to time but, when the

rock mechanics committee got into its stride, this meant dealing with another remarkable and gifted man who was a real "loner" and with whom dialogue was impossible. It has been, therefore, with the very greatest pleasure that I have followed recent developments which give promise of healing this breach, now that both the men I have had to mention have passed on.[76]

[Local Geotechnical Groups]

The third disappointment arose in connection with the Local Geotechnical Groups, the formation and development of which gave to the Associate Committee such special pleasure. Having had the pleasure of speaking with all the Groups (possibly with one exception), I know well how much they have done in promoting the proper appreciation of Geotechnique across the country; they are a significant part of the geotechnical scene.[77] But I have had nothing to do with their development directly; others can tell their tale. Just before the l969 annual Soil Mechanics Conference in Kingston, we heard that a very small group of engineering geologists in Montreal was going to form a Branch of the Association of Engineering Geologists.[78]

This fine body started in the 1950s, as the California Association of Engineering Geologists, as a result of legislation passed by Los Angeles County—I think—regarding engineering geological services. It soon dropped the "California" from its title and added "American." Being guided, for a time, by good men who had no knowledge of international affairs, they soon started calling themselves an international body, promoting the establishment of overseas Branches. There is one in South Africa and one in the United Kingdom, each filling a gap.

It has, however, been a firm policy, for almost a century, for all the main scientific and engineering societies of the USA—with one strange and unusual exception, IEEE[79]—to welcome Canadian members but never to form branches or sections in Canada, in consideration of Canadian susceptibilities. The *[American Society for Civil Engineering and the Geological Society of America]* are prime examples; Canadian members are included in the contiguous US regions; Canadians have been Presidents of each body.[80]

But, AEG, being a young organization—still "geared to the West"—knew nothing of this and so welcomed the overture from Montreal. In loyalty (maybe misguided) to my fellow Canadians, I could never bring myself to tell my good friends, the successive officers of AEG to "lay off" Montreal. I should, perhaps, add that since they honoured me by making me an Honorary Member, I was in a slightly invidious position**!**[81]

I feel it necessary to make this long diversion since this is a part of what I carefully explained to Hugh Grice,[82] one of the prime movers of the Montreal AEG unit, outside the Holiday Inn in Kingston at the time of the 1969 Conference. This was, naturally, a civilised dialogue as compared with my "rock mechanics talk." Hugh knew that this was the first, and still the only, unilateral such movement in the entire history of Geotechnique in Canada...but nothing

that I said would move him. The unit was established, Marc Boyer being (I think) the moving spirit.[83]

[The Montreal unit] is often hailed as proving how "international" AEG really is. But it remains a very small group, with no more than twenty members, so I have been told. The climax was the so-called joint meeting in Montreal in 1982, joint as a result of a diplomatic gesture (I believe) on the part of the CGS. But it was not a joint meeting at all; some AEG members came away from Montreal with no knowledge of CGS! And, the very idea of the two similar societies having their annual dinners in adjacent rooms in the same hotel on the same evening is so Gilbertian[84] a situation that I would not have believed it, had I not been in the embarrassing position of being expected to attend both dinners!

This whole lamentable business must be due to some failure of mine; I still hope that I can help in correcting it. One glimmer of hope is that Pierre Crepeau *[a member of the Montreal AEG unit]* did attend the business meeting of the Engineering Geology Division of CGS and was much impressed. I do so hope that the Montreal Group *[of the Canadian Geotechnical Society]*, aided perhaps by the *[CGS]* Engineering Geology Division, can persuade the AEG unit to "get together" with CGS. I am ready and anxious to do what I can to help, even so late in the day; I am already dropping hints to AEG officers, on the *[subject]* of Montreal, which makes it now a little easier for me to speak.[85]

This was a failure, minor perhaps, but still something that I regret. I feel sure that there must have been other failures or omissions in the thirty-five-year history of "organised Geotechnique" in Canada for which I must accept some if not most responsibility. Let me mention two of which I am aware.

[Tunnels]

Tunnels constitute the major Geotechnical projects in any country. Quite some years ago, Don MacDonald[86] and I talked about this and decided that the first step to take in "doing something about it" would be to compile a Directory of Tunnels in Canada. We did, I think, make a start but I got side-tracked at a very busy period in the *[Division of Building Research's]* history. When we were ready to pick up the threads again, so to speak, we found that a Tunnelling Office had been established within the Department of Energy, Mines and Resources (I think the new name had then come into use) and so we let the matter drop. Readers may judge my surprise when I found that nobody knew anything about such an inventory when I came to inquire during the course of writing an Introduction for the pending Tunnelling Manual.[87] Accordingly, I am just delighted to know that the *[Canadian Geotechnical]* Society now has a tunnelling Committee, working in concert with the newly formed Tunneling Association of Canada,[88] a useful and natural extension of geotechnical activity. To be continued...

[Landslides]

Landslides, which have caused so much trouble in Canada, constitute another problem area to which we might well have given more attention. I have a vague idea that, in the very early days, the *[Associate]* Committee did have a subcommittee on Landslides *([Bill Eden]* will know) but it could not have done very much since it did not continue. And so, again, I am delighted to know that the fourth International Landslide Symposium is to be held in Toronto in 1984.[89] Possibly this will re-activate corporate interest in the subject in Canada to which I wish the Associate Committee had been able, years ago, to address more effectively.

After these gloomy thoughts about "things left undone which I ought to have done," let me turn to two other things that we did do.

[Canadian Geotechnical Journal]

The matter of publishing results of research arose at the very start of the Committee's work, I believe at its second meeting. We followed an established NRC practice of using mimeographed, well bound Technical Memoranda;[90] the list of these committee publications is now an impressive one. They were satisfactory for recording the early work, and records of useful meetings, but something more, and better, was needed. This became a regular matter of discussion at the semi-annual meetings of the Committee but the subject was a complex one and so no action resulted in the 1950s. Much interest in the subject was evident in the Toronto Group, (the late) Larry Soderman and Vic Milligan (I think) being prime movers.[91]

To explain the complexity of the situation, I must again diverge to record that the same problem was being faced in the Division of Building Research. Dr. Hutcheon (Asst. Director) and I had many talks on the matter. We were getting papers published on building research in reputable US journals but, naturally, wished that there was a Canadian medium that we could use. The Council itself was well launched with its Canadian Journals of Research *[series]*—but the six sections in which this was then published were all in the field of "pure" science (Physics, Chemistry, Biochemistry, Physiology and Pharmacology, Botany and Zoology). There was, in addition, a *Canadian Journal of Technology* which was a sort of catch-all for papers that did not fit into the other journals. We never did find out who had started it, or who had chosen the regrettable name of "Technology" (then, and possibly still, looked upon by "pure" scientists as a minor form of plumbing and equally disliked by engineers).

We discussed the situation with Dr. Steacie. He was sympathetic and finally agreed with me that we could "take over" the *CJT* and convert it into a *Canadian Journal of Applied Science*. Once well established, it would be a natural development for specialist fields in applied science to "hive off" with their own journals, one field being (naturally) Geotechnique. This seemed to be the answer but, to our amazement, when we came to take the first steps, we found that *CJT* had been given lock, stock and barrel to the Canadian Institute of Chemistry to develop as they pleased, independent of the *[National Research]* Council. This step was taken by Dr. Leo Marion, the Director of the *[NRC's]* Division of Chemistry and Editor-in-Chief of the *[NRC]* Journals,

apparently without the knowledge of Dr. Steacie. We were most annoyed, but there was nothing to be done but to accept the situation and start all over again.

I am not exactly sure of the detailed steps that led to the start of the *Canadian Geotechnical Journal*, but I have a vivid recollection of Larry Soderman coming to a meeting of the Committee, with his usual "divine" impatience over the lack of action by the Committee, only to find that we were all thinking along the same lines. I had further talks with Dr. Steacie, just before his lamentable terminal illness (he died, to universal regret, in 1962) and we argued (as we always did) about the best way to proceed. He would not agree to start a new section of the Canadian Journals of Research (maybe the memory of the disposal of *CJT* was still too vivid) but he did agree with the Associate Committee starting a journal, to the same high standards, if we could finance it ourselves, and if I would guarantee to him that we had enough papers in view for two whole years before we launched the first issue! (What a man he was! I argued strongly against the latter provision, but he was right—so right, as other fledgling journals have discovered.)

This was reported to the Committee and then things moved. Here memory is a bit hazy but I feel sure that we were indebted to the Toronto Group for much, if not all, of the effort which went into the start of our Journal.[92] The first issue appeared in September 1963, graced with a Foreword by Dr. Terzaghi;[93] Volume 2 started with the first issue of 1965 and thereafter volumes coincided with years. Not until Volume 6 did the editor's name appear—and this was (I think) in the first volume to be published directly by the *[National Research]* Council, as a part of Canadian Journals of Research *[series]*, since our Journal had by then "won its spurs." Fred DeLory was the editor so named but I am almost sure that Vic Milligan served as the founding editor, assisted by Fred DeLory, Pierre LaRochelle, Carl Crawford and Don Bazett, these being the names inscribed in the specially bound copy of the first volume that was so kindly presented to me on 5 March 1965.[94]

Once again, as was inevitable I suppose, we did not realise what a significant step we were taking. The *Canadian Geotechnical Journal* was, I think, the first journal to be published in Canada in the field of applied science. During the planning stages I kept in close touch with Dr. J.M. Harrison, Director of the Geological Survey of Canada. Together, I think, we had discussions with Dr. Steacie who agreed that the "pure" Earth Sciences could have a new Journal as a part of the Council's CJR series. It was therefore agreed, between J.M.H. and me, that the *Canadian Journal of Earth Sciences*[95] and the *Canadian Geotechnical Journal* would be closely complementary, the one taking purely scientific papers, the other papers in all applied fields of all the Earth Sciences. This is clearly stated on the first page of the first issue of the *Canadian Geotechnical Journal* but I have found recently that it is quite unknown to those responsible for the Journals today. The link should be so stated on both title pages. (I propose to follow this up).[96] The Geotechnical Journal was first in print by a few months.

The *[Canadian Geotechnical Journal]* was the first NRC journal to use our second language, and in its title, too.[97] It was the first NCR journal (*[because]* the Associate Committee was at first

responsible) to include discussions of papers, something previously unknown. It also published Book Reviews. After some discussion these "novel" gestures were continued when the Journal was taken into the CJR fold. Having made these really great advances, we had to "back off" from publishing Obituaries (such as for Bob Peterson) and, to my profound regret, this alienated Dr. Hugh Golder, but there was nothing I could do to change this.[98]

Others can give the full story of the Journal but I must record my great pleasure at the splendid job done by successive editors in developing its present international reputation. In several countries other than Canada I have heard its praises sung, several leaders in Geotechnique telling me that it is now the only geotechnical journal they read, since it has so well kept a balance between theory and practice, other journals having become almost entirely theoretical. Long may it continue to do so.[99]

[Canadian Geotechnical Conferences]

The annual conferences call for some further comment, even though I have already mentioned them briefly. The tenth such meeting seemed to us, at the time, a great milestone! And so, greatly daring, we invited Dr. Terzaghi to come and this he did, to our great pleasure. The dinner was held on 17 December 1956 in the Chateau Laurier and it proved to be a delightful affair, graced by the presence of the Honorable Robert Winters,[100] then Minister of Public Works, Dr. Steacie as President of the Council, Dean Henri Gaudefroy then (I think) still at École Polytechnique[101] and Dr. Terzaghi.[102] Our guest spoke, for an hour and three quarters without a note, on geotechnical aspects of the Aswan High Dam,[103] one of the finest technical addresses I have ever heard. It was a notable occasion in itself but notable also in that this was one of the first "exposures" Dr. Steacie had to applied science at its best.

And I am now convinced that it proved of real assistance to him, when he was appointed President, following Dr. Mackenzie's departure (at Dr. Howe's behest) to be President of Atomic Energy of Canada Ltd. *[Steacie]* was a pure scientist of the pure scientists.[104] I even heard him "glory" in the fact that he "never attended committee meetings." Within five years, this very great man was the acknowledged leader of all the scientists of Canada—as I was told by another leader in the field in a moving telephone call just after Steacie's death was announced. Despite his having told me that Building Research was merely glorified plumbing (in the provocative way in which he used to talk with me) and his initial disdain for "messing about with mud" *([Steacie]* used the expression too), it was not long before he became the strongest supporter that DBR/NRC could possibly have wished to have, equally so of the Associate Committee and its work. I am confident that the tenth anniversary dinner helped.

Correspondingly, we were given full support when the time came (in or around 1962) that the annual conferences had become so successful and so well attended that it was clear they must be passed on to some other body. This was the start of the Canadian Geotechnical Society,[105] another rewarding development to watch; the success of which is for all to see, with almost fifty

percent of its members attending its annual conference, on occasion, something unknown to me in any other society.

Again, I was an observer to all this but I must record that the two-year transition period for the annual conferences to get ready to "stand on their own feet", and the associated establishment of CGS,[106] were entirely in the tradition of the *[National Research]* Council's operations. There were some, who did not know the Council well, who thought at the time that NRC (and maybe DBR) was just "washing its hands" of what had become a burden. Exactly the opposite was the truth; it was all done with full support from the Council. This was, I think, the first such development in a field of applied science, but both the Defence Research Board and the Medical Research Council, not to mention Atomic Energy of Canada Ltd., had all "hived off" *[from]* NRC in the same way, to the Council's pleasure, and in keeping with its *modus operandi* of stimulating research in Canada.

The one thing we could not have foreseen was the way in which the Engineering Institute of Canada would change[107] ...but that is another story which has not affected the steady and fine progress of the Canadian Geotechnical Society, the culmination of the development from such small beginnings that has been so roughly sketched in these pages.

Associate Committees in General

Now that the Associate Committee is again "just a committee" (a lamentable expression but one for which I can not think of a better alternative), a final word about Associate Committees in general may be of service. From time to time attacks are made upon this unique committee structure; I have even had to listen to a former member of our own Associate Committee make such an attack in public. All the committees are reviewed from time to time, as they should be, and their continued existence considered. Such sensitivity is all to the good and is one of the strengths that makes NRC Associate Committees, as a whole, quite the most remarkable and useful agency of their kind that I have ever encountered in any country, so much so that I earnestly hope that they long continue to provide the national service that they do.[108]

In the course of my duties for the Council it was my good fortune to visit many countries overseas, as well as the United States quite regularly, and not only to make such visits but to come to know leaders of research in many lands. Again and again I have been asked how Canada managed to achieve so much in research with so small a population (relatively) occupying such a vast territory, questioners comparing their more compact spheres of action with ours. It was in this way that I came to see the special value of the Associate Committee arrangement to Canada, being led to explain its salient features in answer to probing questions. The first Associate Committees were established by NRC before the second world war and some did useful work. It was, however, during the years of the 1939-1945 war that they really came into their own, under the watchful eye, and full support of Rt. Hon. C.D. Howe, as Dr. Mackenzie told me on more than one occasion.

The basic concept of getting together in the same room the best brains in the country in any one specific field, to discuss problems from the national point of view, is so simple that it was strange to have to explain it to others. The appointment of members to committees only as individuals, and never as representatives, was one of the keys to success. Payment of travel expenses, to well defined and sensible guidelines, conquered our geographical limitations. Service on the committees voluntarily, and with no payment for time—despite the great value of the time given by every member—was another basic assurance of impartial good judgement on the problems addressed. And regular rotation of membership gradually but steadily developed a nation-wide fraternity (and I choose that word) in each particular field. If ever an example is needed of all that is best in NRC Associate Committees, ACSSM can be well to the fore in any selection.

Annotations Chapter 15: THE ASSOCIATE COMMITTEE

[1] The Associate Committee on Soil and Snow Mechanics was renamed the Associate Committee on Geotechnical Research in 1965.

[2] V-E Day (Victory in Europe Day) was on May 8, 1945; V-J Day (Victory over Japan Day) was still several months away (see later annotation).

[3] The Library and Archives Canada has most of the records of the Associate Committee on Soil and Snow Mechanics (1945-1965) and the Associate Committee on Geotechnical Research (1965-1990), including the minutes of all the meetings. The contents of the LAC files are listed on the CGS website (Virtual Archives). See Chapter 24.

[4] Peckover did review Legget's memoir and did make a few changes and corrections. These are incorporated into this book.

[5] Neil Barron Hutcheon (1911-1989) received his bachelor's and master's degrees in mechanical engineering from the University of Saskatchewan and his PhD from the University of London. He joined the faculty of U of S in 1937 and remained there until 1953, when he was appointed Assistant Director of the NRC/DBR. Hutcheon worked at the DBR for 24 years. When Legget retired in 1969, Hutcheon succeeded him as Director. His technical interest was associated with heat and moisture problems in buildings (University of Saskatchewan website).

[6] Legget did find a copy of Hutcheon's note of appreciation of the Associate Committee and included it as Appendix B in his memoir (see Chapter 18).

[7] This counter-offensive was known both as the Ardennes Counter-offensive and the Battle of the Bulge. It was the last major German offensive campaign on the Western Front during the Second World War, taking place from 16 December 1944 to 25 January 1945. The offensive was intended to stop Allied use of the port of Antwerp, Belgium, and to split the Allied forces. Eventually unsuccessful, it resulted in over 100,000 casualties on both sides (Wikipedia).

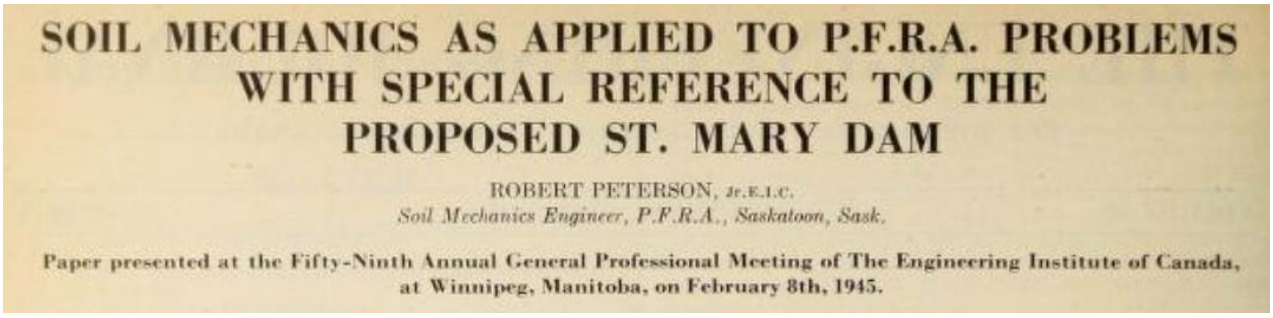
[8] Albert Edward Macdonald (1900-1963), a structural engineer, joined the Civil Engineering Department at the University of Manitoba in 1923, became department head in 1936 and was the second dean of engineering (1949-1963). He died in office. An engineering building on campus is named after him (University of Manitoba website).

[9] Robert (Bob) Peterson (1918-1969) was a 1939 civil engineering graduate of the University of Saskatchewan. He joined the Prairie Farm Rehabilitation Administration (PFRA) and developed a great interest in soil mechanics. Following up on his interest, Peterson took graduate studies under Karl Terzaghi and Arthur Casagrande at Harvard University, earning a master's degree in civil engineering in 1941. Upon returning to PFRA he became chief soil mechanics and materials engineer responsible for all investigations and research in soils and concrete and for the design of earthworks for numerous projects. Peterson was awarded, posthumously, the 1st Robert F. Legget Award in 1970 (CGS website; Lives Lived).

The PFRA was established by the federal government in 1935 in response to the widespread drought, farm abandonment and land degradation of the 1930s. Its purpose was to promote sustainable development on the prairies, in part by developing water supply and soil conservation projects. The PFRA was phased out in the early 2010s (Wikipedia).

Gerry Williams was a materials engineer with the Highways Branch of the Manitoba Department of Public Works.

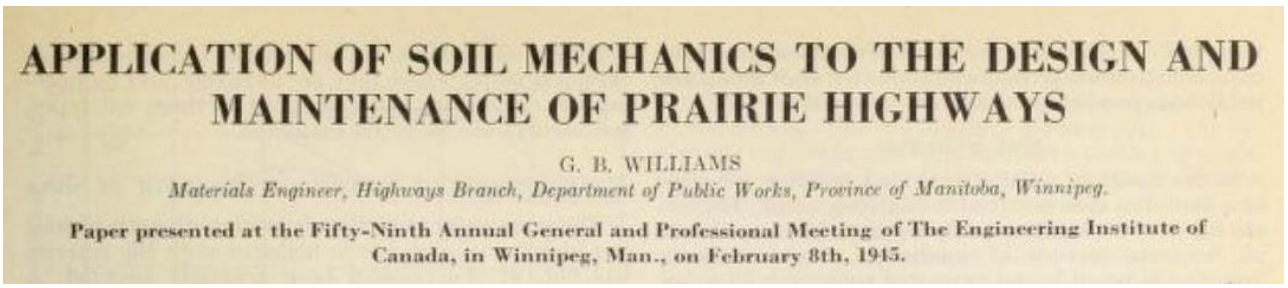
[10] Both papers were published in Volume 28, the May 1945 issue of the *Engineering Journal* (pp 274 and 288, respectively).



SOIL MECHANICS AS APPLIED TO P.F.R.A. PROBLEMS WITH SPECIAL REFERENCE TO THE PROPOSED ST. MARY DAM

ROBERT PETERSON, Jr.E.I.C.
Soil Mechanics Engineer, P.F.R.A., Saskatoon, Sask.

Paper presented at the Fifty-Ninth Annual General Professional Meeting of The Engineering Institute of Canada, at Winnipeg, Manitoba, on February 8th, 1945.



APPLICATION OF SOIL MECHANICS TO THE DESIGN AND MAINTENANCE OF PRAIRIE HIGHWAYS

G. B. WILLIAMS
Materials Engineer, Highways Branch, Department of Public Works, Province of Manitoba, Winnipeg.

Paper presented at the Fifty-Ninth Annual General and Professional Meeting of The Engineering Institute of Canada, in Winnipeg, Man., on February 8th, 1945.

[11] Legget describes his involvement with the Steep Rock Iron Ore Mine in Chapter 11.

[12] Don C. Rose worked with the NRC Physics Division from the 1920s to 1966. At the time to which Legget refers, Rose was the Special Assistant to C.J. Mackenzie, NRC President. Among other achievements, Rose initiated Canada's space research and was the Chair of the Canadian Organizational Committee for the International Geophysical Year in 1957 (NRC Archives).

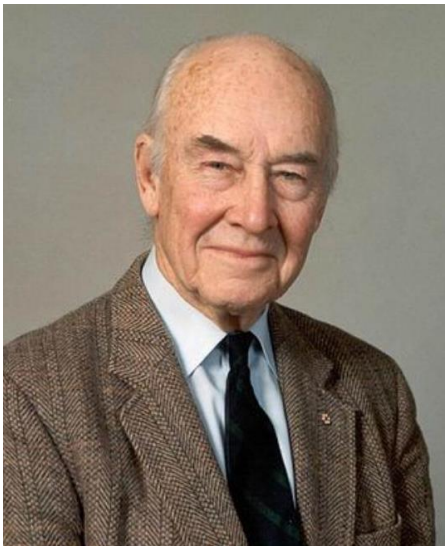
[13] Robert (Bert) Edward Jamison (1891-1970) graduated from McGill University in applied science in 1914. After the First World War he joined the faculty of McGill's Department of Civil Engineering in 1920. During the Second World War, Jamieson was Director-General of Army Engineering for the supply branch of the Department of Munitions and Supply. He served as Dean of Engineering of McGill from 1952 until 1957 (McGill University website).

[14] Gordon McIntosh Letson (1901-1999) was a 1926 mechanical engineering graduate of the University of British Columbia. In the late 1800s, his father started Letson and Burpee, an engineering and machinery manufacturing company. Except when he served in the army during the Second World War, G.M. Letson worked for Letson and Burpee, serving as president from 1950 until he retired in 1975 (Legacy Obituaries website).

[15] Franklin Delano Roosevelt (1882-1945) was the 32nd US President. Earlier in his life, he contracted a paralytic illness, believed at the time to be polio, and his legs became permanently paralyzed. A heavy smoker his entire life, his health started to deteriorate in 1940, got worse in 1944 and he died on April 12, 1945 (Wikipedia).

[16] Roosevelt's Vice President and successor was Harry S. Truman, who served as the 33rd US President from 1945 to 1953.

[17] John Tuzo Wilson (1908-1993) was a geophysics and geology graduate from the University of Toronto, University of Cambridge and Princeton University. During the Second World War, he served in Canada and Europe as a colonel with the Royal Canadian Engineers. After the war, Wilson was the University of Toronto's first Professor of Geophysics and became president of that university from 1967 to 1974. In 1974, he became the Director General of the Ontario Science Centre and in 1983 the Chancellor of York University. He contributed significantly to the geological theory of plate tectonics (Wikipedia).



J. Tuzo Wilson in 1992 (photo source Wikipedia)

[18] George Johann Klein (1904-1992) was a mechanical engineering graduate of the University of Toronto. He worked for forty years (1929-1969) in the NRC Mechanical Engineering Division in Ottawa. He invented, or made significant contributions to, the first electric wheelchair for quadriplegics, the first microsurgical staple gun, the ZEEP nuclear reactor (the precursor to the CANDU reactor), the international system for classifying ground-cover snow, aircraft skis, the Weasel all-terrain vehicle, the STEM antenna for the space program and the Canadarm (Wikipedia). Lionel Peckover remembers Klein designing the first modern kamitik (traditional Inuit sled) for the RCMP.

[19] Peckover is introduced in Chapter 14 and its annotations.

[20] The Rideau Club is a private social club in downtown Ottawa. It was founded in 1865 by John A. Macdonald, soon to be the first Prime Minster of Canada. The original club building burned down in 1979 (Wikipedia).

[21] $15,000 in 1945 would be approximately CDN$200,000 in 2020.

[22] In 1987, Legget wrote about the name that Mackenzie suggested, “and so he used the name as a ‘disguise’ (for want of a better word) for a smaller group of six, with me as Chairman, charged with a top-secret wartime research task” (Letter to *Geotechnical News*, 27 June 1987).

[23] For a first-hand description of this “lamentable disastrous twenty-fifth anniversary dinner … that awful evening” see “The ‘Lamentable Disastrous’ Canadian Geotechnical Conference 25th Anniversary Banquet, ” by Don Shields *Canadian Geotechnique/Géotechnique canadienne*, Vol 1, No 2, pp 18.

[24] C.J. Mackenzie died in 1984.

[25] This course taught by Legget is described in Chapter 12.

[26] Up to this point in time (1945) all Legget’s Canadian travel was by train, his preferred mode of travel.

[27] The Vehicle Proving Grounds, part of the Department of National Defence, were located west of the town of Orleans, ON, approximately 10 km east of Ottawa. Among other things, the grounds were used to test tanks and other tracked vehicles. The site is no longer the responsibility of DND and is currently used by the RCMP as a Technical and Protective Operations Facility (TPOF) (Wikipedia).

[28] Alfred Leahey (1900-1981) was a soil scientist, a lecturer and research assistant with the Alberta Department of Soil Science from 1930 to 1936. He subsequently joined the federal Department of Agriculture and held supervisory positions in pedology with the Experimental Farm Service (1936-1959) and the Research Branch (1959-1966), both in Ottawa. For many years he served as Chair of the National Soil Survey Committee (University of Alberta website).

[29] Many war historians now regard August 14, 1945 as V-J Day, the day Japan initially surrendered. September 2, 1945 was the day Japan signed the surrender documents.

[30] Two nuclear weapon tests were conducted near the Bikini Atoll, one on the Marshall Islands, in mid-1946. These were the first peacetime nuclear tests. Twenty-one additional tests were carried out up until 1958. Before testing began, all residents were removed, could not return and have not returned to the atoll (Wikipedia).

[31] Legget expands on the concept of the "spaced-link track" later in this chapter.

[32] Don Nazzer (1918- 2005) was a 1941 mechanical engineering graduate of the University of British Columbia. He spent the early part of his career with the NRC and was a close associate of George Klein. Among other projects, Nazzer was involved with Canada's nuclear program and the wind tunnel for the Avro Arrow project (NRC Archives).

[33] More will be said about M.G. Bekker later in this chapter.

[34] Norman William McLeod (1904-1989) was a chemistry graduate of the University of Alberta (bachelor's 1930), University of Saskatchewan (master's 1936) and the University of Michigan (ScD 1938). Most of his career was associated with the geotechnical design of asphalt paving mixtures for roads and airfields. He worked with the Saskatchewan Department of Highways, Imperial Oil and McAsphalt Industries. McLeod was the recipient of the 3rd CGS Robert F. Legget Award in 1972 (CGS website; Lives Lived).

[35] Norman William Radforth is introduced in Chapter 11 and its annotations. Lionel Peckover, Secretary to the ACSSM at the time, remembers that his most difficult task as secretary was "translating Norman's writings into a less academic style. I once ran a 'fog index' on one of his pieces …. It scored 22!" (The fog index is a readability test for English writing. It estimates the years of formal education a person needs to understand the text on the first reading. A score of 17 is as high as the index goes and, therefore, Peckover's comment was likely tongue-in-cheek).

[36] In 1947, P.O. Ripley was the Director of the Division of Field, Husbandry, Soils and Agricultural Engineering at the Experimental Farms Services of the federal Department of Agriculture in Ottawa. One of his areas of research was the association of agriculture with climate (Wikipedia).

[37] The minutes of the prior 17 meetings were "classified" for military purposes. This classification was not removed until the late 1940s or early 1950s.

[38] William J. Eden (1926-1994) was a civil engineering graduate of the University of Toronto. He had taken a few courses from Legget before Legget left U of T in 1947. Eden spent his entire career with the NRC/DBR. Technically he was involved with landslides, shrinking and swelling clays and shales, varved clays and in situ testing techniques. In addition to his many years associated with the Associate Committee, for many years he was editor of the *CGS News* and its predecessors. CGS website; Lives Lived).

[39] Lorne Gold was introduced in Chapter 14 and its annotations. In 1982, Gold was Chair of the Associate Committee and his colleague Carl Crawford was Director of the NRC/DBR. Legget likely made this statement tongue-in-cheek.

[40] It is not known what Legget's "ace of spades" was, except that he knew he was retiring in 1969.

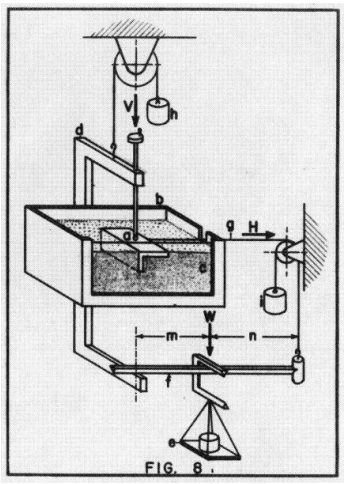
[41] Carl Crawford was introduced in Chapter 14 and its annotations.

Track Studies

[42] Grousers, also called lugs, are protrusions on the steel plates (track shoes) of a tracked vehicle. They increase traction in loose or soft soil or snow.

Grousers on the track of a bulldozer (photo source Duratuff Products)

[43] This figure is a sketch of the soil box apparatus used to test grousers in Legget's University of Toronto soils laboratory.



The grouser being tested is the inverted L-shaped metal bar in the soil box. From *Fundamentals of Soil Action Under Vehicles (Part One)* by R.F. Legget and M.G. Bekker, November 1946, NRC/DBR TM #6.

[44] A "conventional track" is made up of steel plates (track shoes) attached to track links. Track links are similar to the links of a bicycle chain. Grousers can be attached to the steel plates for more traction. A "spaced-link track" is made up of steel bars attached at a regular spacing to the track links. The steel bars can either be flat, or more commonly 'L'-shaped, to form grousers for more traction. A "spaced-link track" typically has only 30% of the contact with the ground compared to a "convention track" (Wikipedia). Legget is referring to the critical spacing between the steel 'L'-shaped bars, or grousers.

[45] These technical memoranda were all related, in some way, to track studies. Notes on each follow.

TM #1: *Proposed Field Soil Testing Device* – August 1945. Although the testing device was designed by Bekker, Legget prepared this memorandum and it was checked by Bekker.

TM #2: *Ground Failure Under the Action of a Track Grouser* – September 1945. Prepared by Bekker and checked by Legget.

TM #3: *The Interrelation of Soil Mechanics and the Design and Operation of Vehicles* – November 1945. Prepared by Captain "Jake" Kastner and checked by Legget.

TM #4: *Soil Survey of Vehicle Proving Establishment, Ottawa* – October 1945. Prepared by D.L.B. Hamlin and R.B. Belford (two of Legget's U of T students) and checked by Legget

TM #5: *Method of Measuring the Significant Characteristics of a Snow-Cover* – November 1946. Prepared by G.L. Klein of the NRC Division of Mechanical Engineering.

TM #6: *Fundamentals of Soil Action Under Vehicles (Part One)* by Legget and Bekker – November 1946. Legget refers to this as "the vital document."

TM #7: *Preliminary Notes on 'Muskeg' from Churchill* by Norman W. Radforth – March 1947. Contains a foreword by Legget.
TM #8: *Fundamentals of Soil Action Under Vehicles (Part Two)* by M.G. Bekker, Directorate of Vehicle Development, Department of National Defence – June 1947.

[46] Legget thought quite highly of TM #6. When he applied to the University of Liverpool for a merit-based DEng in January 1947 (see Chapter 13), he submitted TM #6, along with a copy of his 1939 textbook *Geology and Engineering* and one other unidentified publication with his application. As noted below, TM #6 was a classified document until the late 1950s. It is not known how Legget got permission to send TM #6 to the University of Liverpool in 1947.

[47] TMs #2, #3, #6, #7, and #8 were considered either as "wartime-restricted" or "classified documents" and were not made available to the public until the late 1950s. See Chapter 24.

[48] The Society of Automotive Engineers was established in New York, with the original name Society of Automobile Engineers. It is now is called SAE International and has approximately 140,000 members world-wide (Wikipedia).

[49] Bekker spent time at both General Motors in Detroit, MI and the US Army's Aberdeen Proving Ground near Aberdeen, MD (Wikipedia).

[50] The paper was written by Legget in August 1951 and titled "Soil Action Under an Anchored Plate." In 1959, Legget wrote an explanatory note that he attached to his draft of this paper (NRC Archives). The note reads:

> It has been decided not to proceed further with the idea of publishing this paper, the history of which is a very chequered one. It is the revised version of Technical Memorandum No. 6 of the Associate Committee on Soil and Snow Mechanics which we could never get declassified by the military authorities. By agreement with Major Bekker, I therefore wrote this paper in 1951 cutting out the classified material in the T.M. The paper in this revised form was cleared for publication on 29 October 1951.
>
> By this time, however, Colonel Bekker had developed his queer ideas regarding publication and letters on file show his violent objection he took to the paper being published in this form. It was therefore held up until he cooled down.
>
> By this time various publications in the States, including some from Colonel Bekker himself, had used information contained in this original paper and this made the question of publication more difficult. …
>
> This brief record is therefore made so that if, in the future, anyone should ever refer to this paper they may know the strange and chequered history of its non-publication. 13 May 1959. R.F.L.

It appears that for at least 8 years (1951-1959), the reasons for the non- publication of this paper bothered Legget.

[51] Mieczyslaw G. Bekker (1905-1989) graduated from Warsaw Technical University (Poland) in 1929, worked in Poland on tracked vehicle research until 1939, then moved to France. In 1942, he moved to Ottawa to work in armoured tracked vehicle research. He joined the Canadian Army in 1943, attained the rank of lieutenant colonel and was decommissioned in 1956 when he moved permanently to the US.

After leaving Canada, he taught at several US universities, worked for General Motors and did contract work for the US Army. He was a leading specialist in theory and design of military and off-road vehicles and was an originator of the engineering discipline called "terramechanics"—the interaction of wheeled or tracked vehicles on various surfaces. Later in his career, Bekker contributed to the design and construction of the Lunar Roving Vehicle used by missions Apollo 15 to 17 (Wikipedia).

The book to which Legget refers is *Theory of Land Locomotion, the Mechanics of Vehicle Mobility*, University of Michigan Press, 1956. A 2nd edition was published in 1962.

Snow Studies

[52] Jean-Frederic Lugeon (1898-1976) was Director of the Swiss Meteorological Services from 1945 to 1963. In addition to this position, he was the author of approximately 180 books and scientific papers and conceived numerous methods of weather forecasting. He was also the leader of several Swiss scientific expeditions, including those to Spitsbergen (an island in northern Norway), the Sahara Desert and Argentina (*The NY Times* Obituary website).

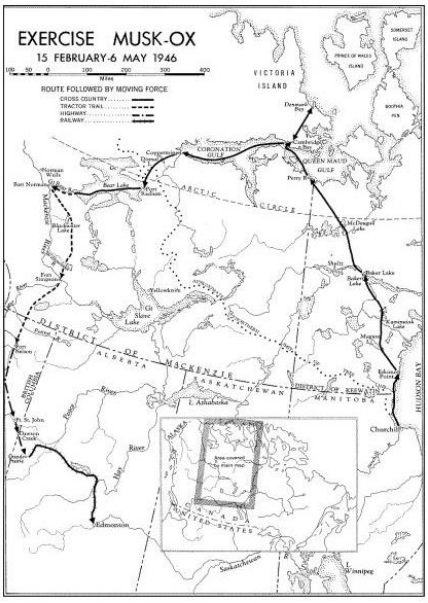
[53] Weissfluhjoch (2,693 m) is a summit in Switzerland. Since 1932 it has been connected to Davos by a funicular (inclined) railway (Wikipedia).

[54] For his research trip to Switzerland, Legget was given the military rank of a colonel.

Legget (wearing sunglasses) testing a carrying seat for wounded soldiers in Switzerland in 1946.
He is wearing a Canadian Army uniform. (photo source NRC Archives courtesy Michael Bozozuk)

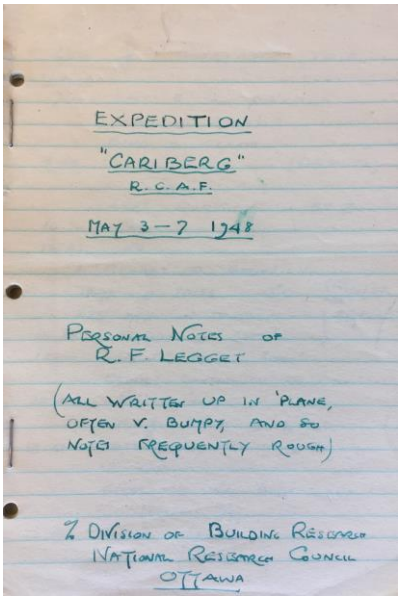
[55] Marcel De Quervain is introduced in Chapter 14 and its annotations.

[56] Exercise Musk Ox involved 48 members of the Canadian Army, one observer from the Canadian Navy, several scientists and three US observers. In 81 days, the participants drove eleven, 4½-ton Canadian-designed snowmobiles, called “Penguins” and one smaller US-designed snowmobile, called a “Weasel,” across the Northwest Territories from Churchill, MB, to Baker Lake, to Denmark Bay on Victoria Island, then south to Kugluktuk, Port Radium, Norman Wells, Fort Simpson (all in the NWT), Fort Nelson, BC, and finally to Grande Prairie, AB. The mission demonstrated that it was highly unlikely that Soviet forces would attempt an overland invasion of North America (Wikipedia). For film footage, see the Youtube Muskox Operation. (The term “Musk Ox” is, in other places, spelt “Muskox” and “Musk-Ox”, and both “Exercise” and an “Operation” are used.)



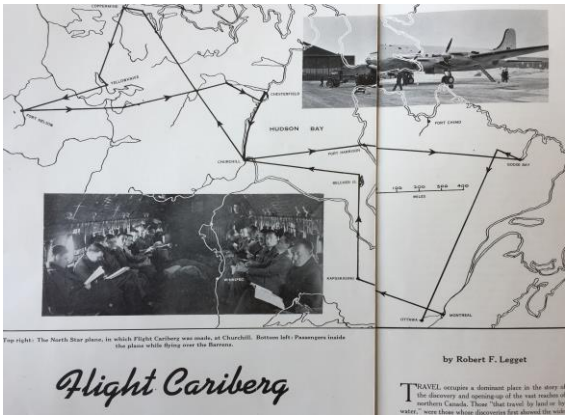
Route of Exercise Musk-Ox. (from C.S. Beals and D.A. Shenstone. 1968. *Science, History and Hudson Bay,* Volume 2, Queen's Printer, Ottawa)

[57] Legget was a member of Flight Cariberg (a contraction of the words 'caribou' and 'iceberg') and kept a journal of this May 1948 trip.



Cover of Legget's Cariberg journal. It states "All written up in 'plane, often v. bumpy, and so notes frequently rough." (LAC 2-6)

The purpose was to make the first Arctic flight of the Canadian-built North Star airplane and to make scientific observations. The 13,000 km-long expedition included 21 passengers, 8 crew and 5 maintenance personnel. Passengers included RCAF personnel, one British and US representative and Canadian scientists—biologists, geologists and meteorologists. One was female. From Legget's 1950 *The Beaver* article: "In 1848, Sir George Simpson travelled from Montreal to the end of Lake Winnipeg and back, and spent 2½ months doing it. In 1948, twenty-one scientists and service officers travelled from Montreal to the Alaska Highway and back, via the Arctic and Labrador coasts, and spent 4½ days doing it."



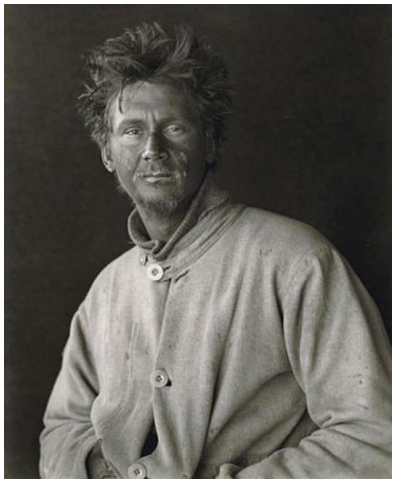
Map from Legget's 1950 *The Beaver* article.

[58] Gerald Seligman (1886-1973) was a British born and educated glaciologist. He founded, in 1936, and was first President of the Association for the Study of Snow and Ice. In 1962, that association changed its name to the International Glaciology Society and the following year Seligman stepped down as president. The Seligman Crystal is awarded by the society in recognition of outstanding scientific contributions to glaciology. He launched the *Journal of Glaciology* in the late 1940s (International Glaciology Society website).

The book to which Legget refers is the 555-page *Snow Structure and Ski Fields—being an account of snow and ice forms met with in nature and a study on avalanches and snowcraft*, published by Macmillan & Co Ltd, London, 1936.

[59] Sir Charles Wright (1887-1975) was born and educated in Toronto (Upper Canada College and University of Toronto) and in England. He was a member of Robert Scott's 1910-1913 expedition to Antarctica as a glaciologist and physicist. He served the British during the First and Second world wars and was knighted after the Second World War for his work on the development of radar and mine and torpedo detection. After the war he moved to the US, where he became Director of the Marine Physical Laboratory of the Scripps Institution of Oceanography at La Jolla, CA in 1951. He joined the Defence Research Board of Canada's Pacific Naval Laboratory in 1955 and in 1967 joined the Institute of Earth Sciences at the University of British Columbia and then Royal Roads Military College in Victoria, BC (Wikipedia).

Wright and Legget became personal friends. Legget visited Wright just before Wright died on Salt Spring Island, BC, where he had retired.



A photo of C.S. Wright taken in 1912 during the Scott expedition
by expedition photographer Herbert Ponting (photo source Wikipedia)

[60] *Glaciology* by C.S. Wright and R.E. Priestley was published in 1922 by Harrison and Sons, London. It was for many years considered the definitive work on the glaciers in Antarctica and was based on the authors' participation in the 1910-1913 Scott expedition. Priestly became Wright's brother-in-law shortly after the expedition.

Muskeg Studies

[61] Radforth is introduced in Chapter 11 and its annotations.

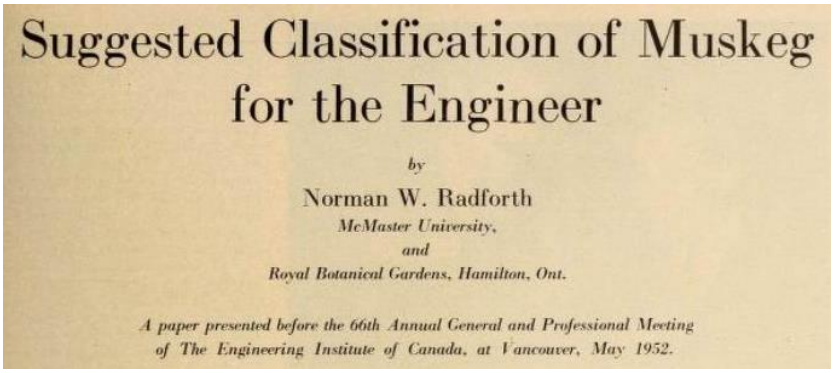
[62] When Legget wrote his memoir in 1983, the 1982 ten-week Falklands War between the UK and Argentina was still fresh in people's minds.

In 1983, Ivan MacFarlane recorded his recollection of Radforth's journey to the Falkland Islands in his interview for the Canadian Geotechnical Heritage Book project. The following is a summary.

> Radforth's trip was in the late 1950s or early 1960s and was funded by an NRC grant, through the Associate Committee of which Legget was the chair. At that time, the Falkland Islands were a British possession and the only means of getting there was by a British Royal Navy supply ship from Uruguay. Radforth decided to take his wife, a noted ichthyologist who was working with the Royal Ontario Museum at the time and who wanted to study fish unique to the Falkland Islands.
>
> They arrived in Montevideo, Uruguay, but were not allowed to board ship because, at that time, women were not allowed on Royal Navy ships. The only exception was if Queen Elizabeth II, the Commander-in-Chief of the British Armed Forces, sanctioned it. Radforth, being the man he was, sent a telegram to the Queen asking for her permission. It turns out that the telegram was directed from the Queen's office to that of the Governor General of Canada. Legget was awoken in the middle of the night by the Governor General's office asking what Radforth's telegram was all about. Legget did not support Radforth's opinion that the regulation should be waived for Mrs. Radforth and, therefore, Radforth went to the Falkland Islands on his own.

[63] The Defence Research Board was established in 1947 and is now known as Defence Research and Development Canada (Wikipedia).

[64] The EIC meeting was held in Vancouver, BC and Radforth's paper was published in the *Engineering Journal* in 1952—"Suggested Classification of Muskeg for the Engineer," Vol 35, pp 1199-1210.



Suggested Classification of Muskeg for the Engineer

by

Norman W. Radforth

McMaster University,
and
Royal Botanical Gardens, Hamilton, Ont.

A paper presented before the 66th Annual General and Professional Meeting of The Engineering Institute of Canada, at Vancouver, May 1952.

[65] Here Legget's memory may have failed him. Within a year of Radforth publishing his first paper in the *Engineering Journal* in 1952, he published a paper in the *Transactions of the Royal Society of Canada*. Radforth did not publish a paper in *Nature* until 1965—a paper titled "Muskeg in North America."

Permafrost Studies

[66] Ivan MacFarlane is introduced in Chapter 14 and its annotations.

Soil Mechanics Studies

[67] The Division of Building Research did not exist at that time.

[68] George Geoffrey Meyerhof (1916-2003) was born in Germany and educated in the UK. He worked with the UK Building Research Station from 1946 to 1953. Meyerhof immigrated to Canada in 1953 and initially worked for FENCO before joining the faculty of the Technical University of Nova Scotia, where he also served as Civil Engineering department head and dean of engineering. He was the first President of the Canadian Geotechnical Society in 1972. In 1974, he was awarded the 5th CGS Robert F. Legget Award. In 1995, the CGS Soil Mechanics and Foundation Engineering Division named its annual award in Meyerhof's honour (CGS website; Lives Lived).

[69] The Canadian Soil Mechanics Conference is now the Canadian Geotechnical Society's annual "Canadian Geotechnical Conference." In 2020, the 73rd conference was held "virtually" because of the COVID-19 pandemic. For more information on the first conference see "The First Canadian Geotechnical Conference (1947)," *Geotechnical News,* September 2019, pp 15-19 by Doug VanDine.

[70] The 2nd Canadian conference, held in Lethbridge, AB, included a field trip to see the construction of PFRA's St. Mary's Dam, approximately 60 km southwest of Lethbridge.

[71] The NRC/DBR published the proceedings of the first 16 annual conferences. They are available online at (see Chapter 24). The proceedings of almost all the annual Canadian Geotechnical Conferences are on the CGS website and available to CGS members for viewing and downloading.

Associate Committee: Operations

[72] James Merritt Harrison (1915-1990) was a geology graduate of the University of Manitoba (bachelor's) and Queen's University (master's and PhD). His field work was primarily in northern Manitoba and Labrador. He worked for the Geological Survey of Canada as a summer student during the late 1930s, then joined the GSC full time in 1943. He was Director of the GSC from 1956 to 1964, then served as assistant deputy ministry in the federal Department of Mines and Technical Surveys from 1964 to 1972. Yves Fourtier succeeded Harrison as Director of the GSC from 1964 to 1973 (*Reading the Rocks, the Story of the Geological Survey of Canada*, by Morris Zaslow, MacMillan Company of Canada, 1975).

[73] Robert Hardy is introduced in Chapter 1 and its annotations.

[74] The 2nd International Conference on Soil Mechanics and Foundation Engineering was held in Rotterdam, the Netherlands, in 1948. Because of the Second World War, there were no conferences held between 1936 and 1948.

[75] The federal Department of Mines was initially established in 1907. Its name was changed to Department of Mines and Resources in 1936, then Department of Mines and Technical Surveys in 1949. This is likely the department name to which Legget is referring. In 1966, the department became Energy, Mines and Resources and in 1993 it became the Department of Natural Resources, as it is known today (Government of Canada website).

[76] For many years, the Canadian Rock Mechanics Association (CARMA) has been composed of two bodies: the Rock Mechanics Division of the Canadian Institute of Mining and Metallurgy and the Rock Mechanics Division of the Canadian Geotechnical Society. CARMA is the Canadian representative body of the International Society of Rock Mechanics.

[77] There are currently 20 CGS local sections across the country. Some local sections are more active than others.

[78] The Association of Engineering Geologists is now the Association of Environmental and Engineering Geologists, but it still uses the acronym AEG (AEG website).

[79] The IEEE is the Institute of Electrical and Electronics Engineers and was established in 1884. The IEEE is no longer limited to only electric and electronic engineers and is open to many other engineering, scientific and even medical professionals. Its mission is to advance innovation and technological

excellence for the benefit of humanity and is the world's largest technical professional society (IEEE website).

[80] The American Society of Civil Engineers, established in 1852, does not keep a list of its past presidents, making it difficult to determine the number of Canadian presidents of the society. As of 2020, the Geological Society of America, founded in 1888 and which does have a list of presidents, has had 13 presidents identified as being Canadian, one being Legget in 1966 (Geological Society of America website).

[81] Legget was awarded an AEG Honorary Membership in 1971.

[82] Reginald Hugh Grice was a professor in the Department of Geological Sciences at McGill University. He was a 1964 PhD graduate of the University of Illinois at Urbana-Champaign, supervised by the well-known engineering geologist Don Deere (University of Illinois website).

[83] Legget is referring to Luc Boyer, not Marc Boyer. Luc Boyer was an engineering geologist who for many years worked with Roctest Ltée, a monitoring and instrumentation developer, manufacturer and supplier founded in Montreal in 1967. He rose to the position of vice-president in that firm. As indicated by Legget, Boyer was the driving force behind the AEG Montreal Section.

[84] Gilbertian refers to a characteristic of the works of English playwright W.S. Gilbert (as in Gilbert and Sullivan), involving ludicrous or paradoxical situations (Wikipedia).

[85] According to the AEG website there are currently no chapters of the association outside the US; however, there is a category of “International Membership.” The Canadian Geotechnical Society currently has an affiliation with the AEG and jointly awards the Robert L. Schuster Medal in the field of geohazards.

[86] Don MacDonald is introduced in Chapter 11 and its annotations.

[87] *Tunnels and Geology in Canada* was published jointly by the CGS Tunnelling Technical Committee and the Tunnelling Association of Canada in 1985.

[88] The Tunnelling Association of Canada was established in 1980 and is the Canadian representative body of the International Tunnelling Association. The CGS no longer has a Tunnelling Committee. The CGS and the Tunnelling Association of Canada have a formal affiliation.

[89] The 4th International Symposium on Landslides was held in Toronto in 1984, in conjunction with the 37th Canadian Geotechnical Conference. The 11th International Symposium on Landslides was held in Banff, AB in 2012 and was organized, in part, by the CGS Landslides Committee.

[90] Most NRC Technical Memoranda are available online (see Chapter 24).

[91] Larry Soderman (1928-1969) was a 1952 civil engineering graduate of the University of Manitoba and did post-graduate work as an Athlone Fellow at Imperial College in London. Upon returning to Canada, he first worked with the consulting firms Racy McCallum, then Trow-Soderman and in 1959 became Chief Geotechnical Engineer of the Ontario Department of Highways. In 1961, Soderman became an associate professor at the University of Western Ontario where he introduced and taught its first soil mechanics courses. He was an associate editor of the *Canadian Geotechnical Journal* from 1965 until his early death at the age of 42. He is credited with helping instigate the formation of the consulting firm Golder Associates in 1960 (CGS website; Lives Lived).

Victor Milligan (1929-2009) was born and raised in Northern Ireland. He obtained a bachelor’s and master’s from Queen’s University, Belfast, in 1951 and 1952, respectively. Coming to Canada after a short time at Purdue University, Milligan worked for the consulting firm Geocon before starting Golder Associates with Hugh Golder in 1960. He worked with Golder Associates for the rest of his stellar career. Milligan was the first Editor of the *Canadian Geotechnical Journal,* from 1963 to 1968 (CGS website; Lives Lived).

[92] Legget helped establish the *Canadian Geotechnical Journal* by also soliciting financial guarantees for the journal’s first two issues from 20 prominent Canadian geotechnical professionals (Crawford 1997).

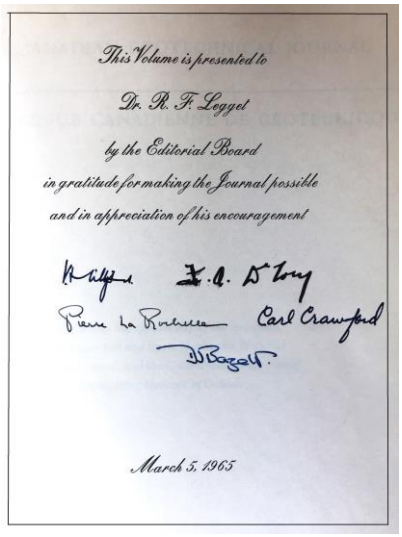
[93] In 1963, Karl Terzaghi was the Honorary President of the International Society of Soil Mechanics and Foundation Engineering. Before his foreword to the journal, there is a full-page photograph of Terzaghi and his handwritten signed note, “To my Canadian colleagues in appreciation of their splendid work.” Terzaghi died a month after the first issue was published.

Legget, as Chairman of the Associate Committee, wrote an introduction to the first issue. From his introduction:

> The journal is intended to provide a medium for the publication of papers in the applied geotechnical field. It is anticipated that most of the papers presented will deal with soil mechanics. In keeping, however, with the liaison with allied fields that has always characterized Canadian soil mechanics work, papers dealing with associated subjects such as engineering geology, pedology, muskeg, hydrology, and the mechanics of snow and ice will always be welcomed by the Editorial Board.

[94] Legget is correct. Milligan was the founding editor from 1963 to 1968, followed by Fred DeLory, who served as editor from 1969 to 1970.

Fred DeLory was a professor at the University of Toronto, Pierre LaRochelle was a professor at Laval University, Carl Crawford worked with Legget at the NRC/DBR and Don Bazett was working with the consulting firm CBA Engineering in Vancouver. Don Bazett became the fourth Editor, serving from 1975 to 1980.



Signed inside cover page of Legget’s specially bound copy of the first volume of the *Canadian Geotechnical Journal.* It reads ”This Volume is presented to Dr. R.F. Legget by the Editorial Board in gratitude for making the Journal possible and in appreciation of his encouragement.” (LAC 18-24)

[95] The *Canadian Journal of Earth Sciences* was first published in August 1964. Since 2010, both the *Canadian Geotechnical Journal* and the *Canadian Journal of Earth Sciences* have been published by Canadian Science Publishing, a private, not-for-profit company that was formerly NRC Research Press, the publishing arm of the National Research Council (Wikipedia).

[96] As far as it is known, Legget did not follow up on this.

[97] The French title is *Revue canadienne de géotechnique.*

[98] Hugh Golder (1911-1990) was a civil engineering graduate of the University of Liverpool (1932). He worked with the UK Building Research Station from 1937 to 1944, then moved to the newly formed UK consulting firm Soil Mechanics Ltd. He was one of the founders of the international journal *Géotechnique*. He immigrated to Canada in 1959 and formed Golder Associates, a consulting geotechnical engineering company, in 1960. Golder was a very highly regarded geotechnical consultant both in Canada and internationally (CGS website; Lives Lived).

[99] Legget's wish has come true. The *Canadian Geotechnical Journal* initially published four issues/year from 1963 to 1989. That increased to six issues/year between 1990 and 2005 and since 2006 it has published 12 issues/year. In the past several years, the journal has typically been ranked second or third by 'impact factor' of all geotechnical journals internationally, and the first or second of Canadian technical journals.

[100] Robert Henry Winters (1910-1969) was a Nova Scotian electrical engineer. He was elected as a Liberal Member of Parliament in 1945 and served as Minister of Public Works, among other portfolios, under Prime Minister Louis St. Laurent (Wikipedia).

[101] Henri Gaudefroy (1909-1992) graduated in civil engineering from École Polytechnique de Montréal in 1933 and later from MIT. He joined the faculty of École Polytechnique in 1939 and served as dean of engineering between 1953 and 1966 (Université de Sherbrooke website).

[102] Photo of some of the individuals Legget mentions.

From left to right: Legget, Robert Winters, Karl Terzaghi, E.W.R Steacie and Henri Gaudefroy at the 10th Canadian Geotechnical Conference, Ottawa, 1956 (NRC Archives)

[103] The Aswan High Dam, built between 1960 and 1970, dams the Nile River in Egypt and drowned the Aswan Low Dam that was completed in 1902. It was first envisioned in 1952 to better control flooding, provide increased water storage and generate hydroelectricity. It has had a colourful technical and political history (Wikipedia).

The reservoir is five times the size of that of Lake Mead behind the Hoover Dam in the US. Terzaghi was a consultant on the Aswan High Dam project and the chair of the associated consulting board starting in July 1954, until the Russians took over the project in 1960 (Goodman 1998).

A summary of the dinner address was published in the "Proceeding of the Tenth Canadian Soil Mechanics Conference," published by the NRC/DBR as TM #46. It was republished in 1983 in the *Canadian Geotechnical Journal, Vol 20*, pp 169-172.

[104] E.W.R Steacie is introduced in Chapter 14 and its annotations. Steacie was educated as a physical chemist, hence Legget's reference to "a pure scientist of the pure scientists."

[105] The Canadian Geotechnical Society was formed in 1972. It developed out of the Engineering Institute of Canada's Geotechnical Engineering Division that was established in 1960 and was encouraged by the NRC's Associate Committee on Geotechnical Research.

[106] The two-year period to which Legget refers was 1961 to 1962.

Between the 16th Canadian Geotechnical Conference in 1962 (organized by, and the proceedings published by, the NRC/DBR) and 1972 when the CGS was formed and assumed the responsibility for organizing the annual conferences, the Engineering Institute of Canada's Geotechnical Engineering Division organized the annual conferences. The proceedings of these annual conferences, from 1963 to 1971, were not published as single, stand-alone documents. Some papers were published as preprints that were given to the delegates at the conferences. At some conferences only abstracts were provided and some of the associated papers were printed in subsequent issues of the *Canadian Geotechnical Journal* and in other journals.

[107] Until the 1960s, the Engineering Institute of Canada was the premier learned society for all fields of engineering in Canada. Starting in the late 1960s, various fields of engineering within the EIC started to form their own organizations and their members left the EIC. This weakened its status considerably and in 1986 the EIC officially became a federation of constituent member societies, currently numbering twelve and representing approximately 25,000 Canadian engineers. In 1987, the EIC ceased publishing the *Engineering Journal* (EIC website).

Associate Committees in General

[108] The Associate Committee on Soil and Snow Mechanics, established in 1945, changed its name to the Associate Committee on Geotechnical Research in 1965. In 1990, the ACGR was disbanded and turned its mandate over to the Geotechnical Research Board of the CGS.

Past ACGR chairmen and technical advisors honoured at a special dinner hosted by Golder Associates at the Rideau Club in Ottawa on August 23, 1991. The photo includes many of the individuals mentioned in Chapters 14 and 15.

From left to right, with years of ACSSM/ACGR involvement: Carl Crawford (1967-76), Victor Milligan (1983-88), Legget (1945-67), Bill Eden (1951-85), Michael Bozozuk (1985-91), Don Shields (1988-91) and Lorne Gold (1976-83; 1988) (photo source Michael Bozozuk)

Chapter 16: DIVISION OF BUILDING RESEARCH YEARS (1947-1969)

Legget and his family packed up and left Toronto in May 1947. They shipped their belongings to Ottawa and travelled by boat to the UK for a family visit and holiday before Legget started his work as founding Director of the National Research Council's Division of Building Research (NRC/DBR) in early August.[1] On returning to Canada, they lived for a short period of time in an apartment in Ottawa until their new house at 531 Echo Dive was completed. In that year, Legget was 43, his wife Mary was 47 and their son David was 13.

531 Echo Drive, Ottawa, Legget's home from 1947 to 1994 (Photo by Doug VanDine, 2019)

The new house was in a middle class neighbourhood on a quiet street overlooking the Rideau Canal. Legget bought the house, which would be worth well over $1 million today, for $4,500. It was only a five-kilometre commute to 100 Sussex Drive, where Legget first worked when he joined the NRC. It was a good choice, and for the next 47 years until he died, it was where he lived and often worked in his study. He wrote the history of the Rideau Canal (*Rideau Waterway*, 1955, University of Toronto Press, 320 pages), one of his most popular books, while living there.

Legget's first task was to establish the DBR. In his memoir (Chapters 14 and 15), he describes the Associate Committee on Soil and Snow Mechanics and the geotechnical-related sections of the division and mentions some of the first geotechnical personnel he hired. But from the very beginning, the mandate of the DBR was much broader than just geotechnical research. It included research on building construction materials and techniques, building standards and codes and fire protection.[2] The breadth of this mandate may not have been appreciated by most Canadian geotechnical professionals.

Legget was also very involved in the design and construction of the new "Building Research Centre" that was constructed on Montreal Road, approximately six kilometres from the NRC's Sussex Drive location.

The October 1953 opening of the "Building Research Centre". Left: Legget at the podium, E.W.R. Steacie and C.D. Howe to Legget's left, unknown individuals to Legget's right. Right: Carl Crawford (left) and Legget (right) showing soil testing equipment to Howe on opening day (NRC Archives)

Because there was more of an emphasis on "buildings" than "geotechnique" in the DBR, in 1953 Legget convinced Neil Barron Hutcheon[3], a Professor of Mechanical Engineering at the University of Saskatchewan, to join the division as assistant director. Legget knew Hutcheon because in 1949 they co-authored a paper, "Conservation in Utilization for Space Heating," for the United Nations Scientific Conference on the Conservation and Utilization of Resources. Legget may have been introduced to Hutcheon through the President of the NRC, C.J. Mackenzie, who was also an engineering professor at the University of Saskatchewan before he joined the NRC in 1939. In 1969, when Legget retired, Hutcheon succeeded him as director.

Under Legget's watch, the DBR staff grew from just himself, when he started in 1947, to 59 professionals and 91 non-professionals a decade later. Of that staff, 14 professionals and 11 non-professionals were working in the geotechnical-related sections. When Legget retired in 1969, the DBR had a full-time staff of 250 and four regional stations in addition to its Ottawa headquarters.

Legget had some office protocols that seem peculiar today, but perhaps were more the norm at the time. For example:

- All staff, professionals and non-professionals, had to sign in in the morning (and the sign-in sheets were removed at 8:15 sharp) and sign out in the afternoon (and the sign-out sheets were not put out until 4:30 sharp).
- All staff were "encouraged" to dress well. Michael Bozozuk remembers returning to the office from doing field work in his field clothes and Legget, walking by him in the hall, making a comment. When Legget next saw Bozozuk, after he had changed out of his field his clothes, Legget commented, "You look much better."
- Ironically, considering where he met his wife, Legget frowned on office romances and when they occurred, the female staff member typically had to leave her job "for the best of reasons."
- Even in the 1960s, when air travel became more popular, Legget encouraged his professionals to travel by train as much as possible "to get a better feel for the land." He even provided his staff tips on how to dress and undress in a berth on a train.

- Ahead of his time, Legget (a non-smoker) discouraged cigarette and pipe smoking in the office.
- Legget made it a policy that he had to review and approve drafts of all DBR documents before they were submitted for publication.
- In the office, he was always referred to as “Mr. Legget” by professionals and non-professionals alike until 1961 when he was awarded his first honorary doctorate (from McMaster University), after which he was always referred to as “Dr. Legget.”

Although some staff resigned over the years, most of both the professional and non-professional staff who were hired during Legget’s 22 years as director remained loyal. Legget was known for not firing anyone, but he was also known for making life “uncomfortable” for several the professional staff who then left of their own accord.

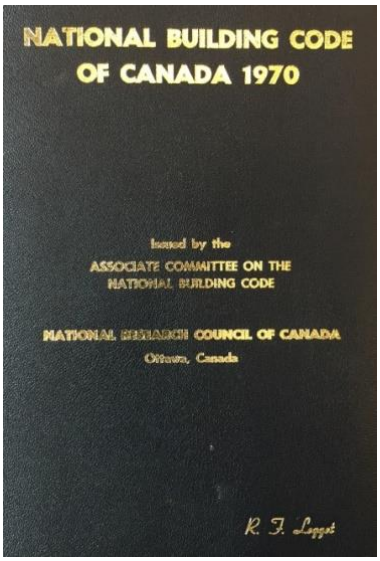
In the geotechnical-related sections of the DBR, professionals who were hired had either bachelor’s or master’s degrees. It was not until near the end of Legget’s tenure as director that the first PhD was hired. Legget encouraged his professionals to further their education by either taking leaves of absences to attend universities outside the Ottawa area or to continue working and take classes at nearby Carleton University or the University of Ottawa. He also encouraged his professional staff to get involved with national and international professional organizations, attend workshops and conferences, participate in field trips and prepare and present papers. One of Legget’s mantras was “good work needs to be published and presented.”[4]

From left to right, Carl Crawford, Legget, Bill Eden and Ed Penner on a Friends of the Pleistocene field trip in 1955 (LAC 18-2)[5]. This field trip was in the St. Lawrence Lowlands in upper New York State. Legget also joined the same field trip in 1959 (Southwestern Ontario) and in 1963 (near Rivière-du-Loup, Quebec).

As Legget describes in his memoir (Chapter 15), in April 1945 he was appointed Chairman of the National Research Council’s Associate Committee on Soil and Snow Mechanics. He continued in that role after becoming director of the DBR and held the position until 1967. In this capacity, he had a direct influence on establishing national research grants in the field of geotechnique (1945), the annual Canadian Geotechnical Conference (1947), the *Canadian Geotechnical Journal* (1963) and the Canadian Geotechnical Society (1972).

The first 16 Canadian annual conferences (1947-1962) were organized under the auspices of the Associate Committee and the DBR published the proceedings. Legget attended 14 of the first 16 conferences and was chairman of the eight conferences that were held in Ottawa. A number of his DBR colleagues assisted in all 16 conferences. As Legget describes in Chapter 15, the 10th anniversary conference, attended by Karl Terzaghi, was one of his career highlights.

Between 1948 and 1970, Legget was also the founding Chairman of the NRC's Associate Committee on the National Building Code. In this capacity, he oversaw the preparation and publishing of the 2nd (1953), 3rd (1960), 4th (1965) and 5th (1970) editions of the *National Building Code of Canada*. He introduced soil mechanics into the 2nd edition. In 1963, for the first time the *National Fire Code of Canada* was prepared and published separately from the *National Building Code*.



Legget's personalized copy of the 5th (1970) edition of the *National Building Code of Canada* (LAC 20-40)

While Director of the DBR, Legget remained a member of the Engineering Institute of Canada and the Association of Professional Engineers of Ontario. He also continued his memberships in other organizations and held positions of significance in many of them.[6]

In addition, Legget represented Canada in an organization he refers to as "the Directors of Building Research in the English-speaking World" and the "Conseil international du bâtiment" when it was formed in 1953. Legget served as president of the latter from 1966 to 1969.[7] Joining and participating in various organizations was one of the ways Legget promoted the DBR to Canadian government agencies and Canadian industries, and one of the ways he promoted Canada and the DBR internationally.

In the late 1950s and 1960s, Legget's involvement in external and especially international organizations increased. He was Vice President North America of the International Society for Soil Mechanics and Foundation Engineering (as it was known until 1998) from 1961 to 1965. He was Chair of the American Society for Testing Materials (ASTM) Committee E-6 on Performance of Building Constructions from 1954 to 1964 before becoming President of the ASTM for 1965 and 1966. In 1966, he was also President of the Geological Society of America. He had been Chair of the GSA's Engineering Geology Division in 1959 and 1960.

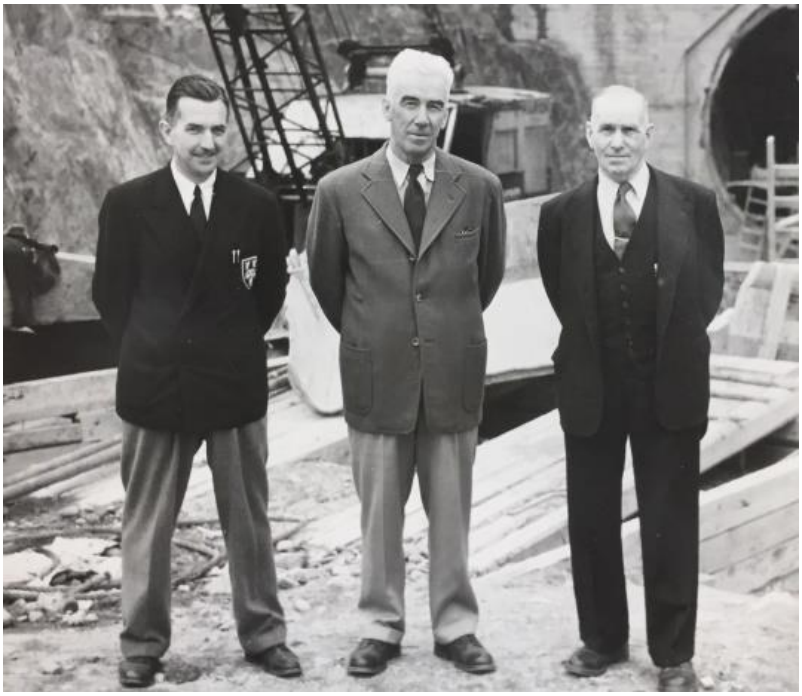
As if these responsibilities were not enough, from 1961 to 1965 Legget was also Chair of Organizing Committee of the 6th International Conference on Soil Mechanics and Foundation Engineering. This conference was held in September 1965 at the Place des Arts in Montreal, the concert hall that had opened only two years before. As alluded to by Legget in his memoir (Chapter 17), this one-week conference was a huge undertaking. More than 1,300 delegates and accompanying persons attended from 50 countries. The three volumes of proceedings included 218 papers and 6 keynote papers presented during the conference.[8]

The conference also honored the life of the founder of the ISSMFE, Karl Terzaghi, who died in 1963. During the event, Karl Terzaghi's wife, Ruth Terzaghi, herself an engineering geologist, unveiled a commemorative plaque renaming the BC Hydro and Power Authority's Mission Dam (in the interior of BC), the Terzaghi Dam.[9] The following year, Legget travelled to the dam site where the plaque was mounted.

Unveiling of the plaque at Terzaghi Dam, formerly Mission Dam, BC, 1966. From left to right, Mark Olsen (Ripley Klohn Leonoff), Legget, Harold Taylor (BC Hydro) and Carl Crawford (DBR) (photo source Klohn Crippen)

After the international conference, Legget had the idea of using some of its proceeds to promote and support geotechnical research in Canada. Five years later, with the help of the Associate Committee on Geotechnical Research, the Canadian Geotechnical Fund (now known as the Canadian Foundation for Geotechnique) was established. Legget also suggested some of the proceeds from the conference be used to support an annual cross-Canada lecture series to be given by prominent geotechnical professionals. In the fall of 1965, the first Cross-Canada Lecture Tour was the result.[10]

Another way in which Legget promoted the DBR was by visiting various parts of Canada. Besides being a part of the Cariberg Expedition in 1948 (described in Chapter 15), he visited Canada's Arctic several more times. He also visited Winnipeg after the 1950 flood, the four possible new town sites for "New Aklavik," NWT (one of which turned out to be Inuvik), Uranium City, SK, as it was under construction and other major construction sites throughout the country.

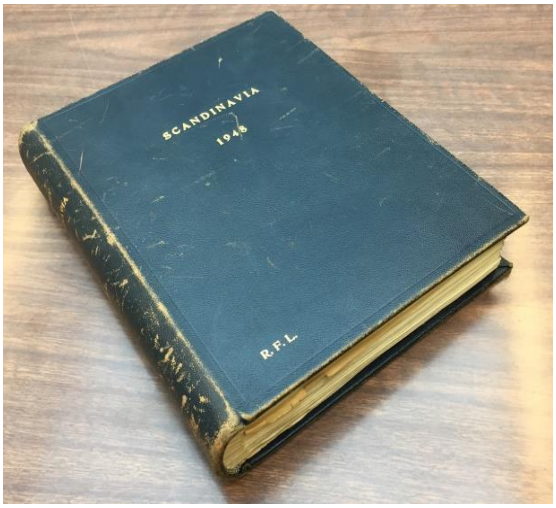


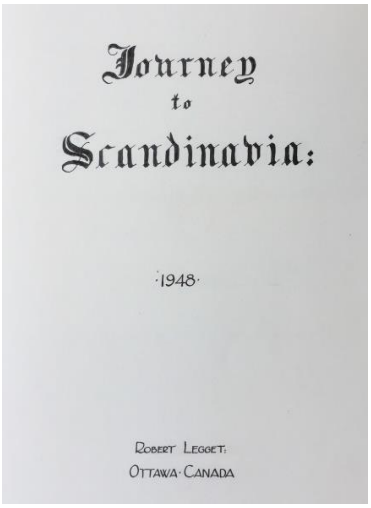
Legget (left) and two unidentified individuals visiting the Rapides-des-Quinze Hydroelectric Power project on the Quebec side of the Ottawa River in 1950.[11]. Note Legget is wearing a blazer with the University of Liverpool coat of arms. (LAC Spec Coll)

Legget also travelled to various technical meetings in Canada and the US, and started to travel beyond North America. For example,

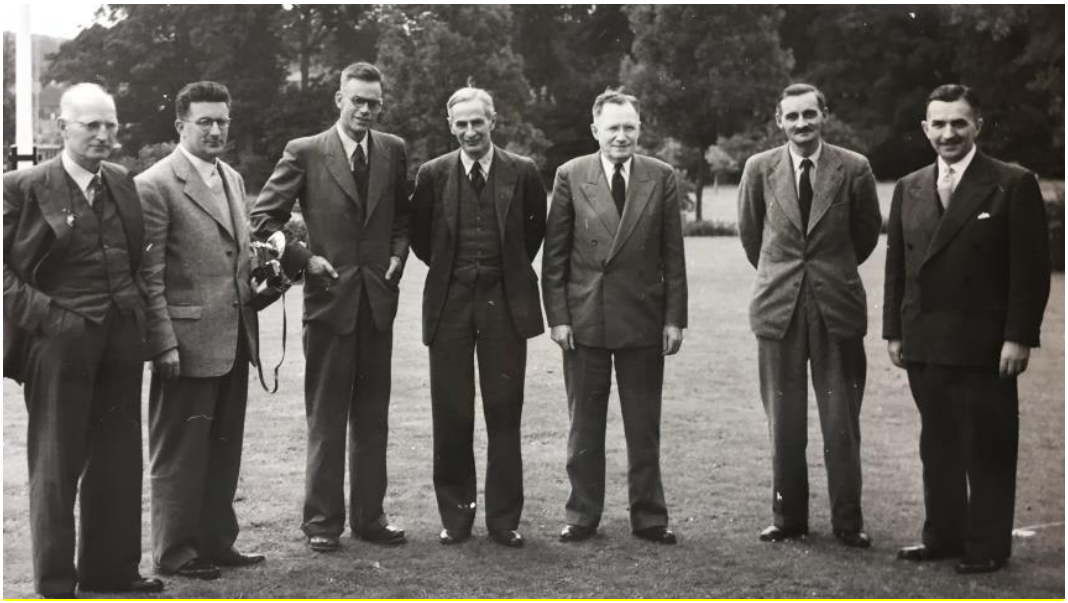
- In 1948, with G.J. Klein,[12] Legget sailed across the Atlantic and travelled for 6 weeks throughout Scandinavia. As in the past for his large adventures, Legget produced a bound journal that included 130 pages and almost 100 photographs.
- In 1951, Legget again sailed across the Atlantic Ocean to visit the British and Scottish Building Research Stations, the British Road Research Laboratory and the British Fire Research Organization, all as part of meetings with the Directors of Building Research of the English-speaking World.
- In late 1956, Legget took advantage of international flights for the first time. He attended a meeting of the Directors of Building Research of the English-speaking World in Australia and travelled there via India and New Zealand. He returned via England, Scotland, Finland, Sweden and Norway, landing in Canada in early 1957. In total, Legget visited 12 research establishments. This was his first of three around-the-world trips. He repeated the experience in 1962 and 1967.

Legget estimated that while Director of the DBR, he travelled approximately 30% of each year. Most of his North American trips were by train—he flew only when he had to. His earlier international trips were by steamship and later international trips were by plane. His wife Mary accompanied him on many of his trips.





Left, bound journal and right, title page of Legget's 130-page "Journal to Scandinavia 1948" (NRC Archives)



Legget (far right) with unidentified Directors of Building Research of the English-speaking World, in the UK in 1951 (LAC Spec Coll)

Legget in India during his 1967 around-the-world trip (NRC Archives)

During his 22 years as director, Legget also promoted the DBR and its work by giving lectures and publishing papers. Among his first lectures were a 1948 presentation titled “Building Research, an outline of the tasks ahead,” and a 1949 presentation titled “Building Research Progress Report 1949.”

Of the many lectures he gave in the following years, three stand out. In 1953, he delivered the 6th Wallberg Lecture at the University of Toronto. The purpose of this lecture series was “to bring to the engineering student, to the teacher and to the practicing engineers the views of men of experience…to provide opportunity for the airing of matters of importance to the engineering profession.” Legget spoke on the topic “Resources for Tomorrow, the Engineer’s Stewardship.” It must have been satisfying on several different levels for Legget to present this lecture to the university at which he had previously taught.

At the end of Legget’s term as President of the Geological Society of America in 1966, he gave a Presidential Address at the GSA annual meeting in San Francisco titled “Soil, its Geology and Uses.” The address was published as a 27-page paper in the *Geological Society of America Bulletin* the following year.

In August 1968, Legget was invited to give a keynote lecture at the 23rd International Geological Congress in Prague, Czechoslovakia (as the country was then known). The lecture was titled “Man as a Geological Agent” and was probably his most memorable lecture. Not only was it given to an audience of over 3,000 delegates from 91 countries—the largest geological event ever held (up until that time)—but, on the night of August 20 shortly after Legget gave his lecture, the Soviet Union army invaded Prague.

The army seized the airport, rail stations, newspapers, radio stations, power stations and public buildings, including Prague’s Technical University where the congress was being held. The remainder of the congress was cancelled. In the following month, Legget wrote a private and unpublished account of the somewhat terrifying events that he and his wife witnessed—“the rape of the lovely city of Prague for the second time in thirty years.”[13]

Photo by Legget, captioned “close up view of Soviet tanks near Technical University, Prague, 21 August 1968” (LAC Spec Coll)

Legget wrote approximately 200 peer-reviewed papers, articles and short notes between 1947 and 1969. Some of those that were not originally published by the DBR were reprinted as DBR technical notes. Approximately 30% were related to geology and geotechnique,[14] 30% to building construction, standards, codes and fire protection, 20% to engineering history, 7% to engineering in society and education and 7% to railways and a few were of general interest. Only one article was related to conservation and none were related to water power, two topics that were of interest to Legget earlier in his career.

Legget's technical contributions were published in trade magazines, and in scientific, engineering and architectural journals. His non-technical contributions were published in diverse ranges of publications including: *Queen's Quarterly*, *Dalhousie Review, Arctic, Nature, New Scientist, Science Forum, Journal of the Newcomen [Historical] Society , Ontario History*, *The Beaver, Saturday Night Magazine* and *The Globe and Mail.*

Throughout this period, Legget continued to be the anonymous Canadian correspondent for the US *Engineering News-Record*. He also contributed some short notes under his name to the same publication.

In 1966, Legget started contributing a series of three- to four-page articles to the *Canadian Consulting Engineer* on various topics related to the history of Canadian engineering.[15] The series was titled "Historical Notes." In his last four years as Director of the DBR (1966-1969), Legget published 23 such notes.[16]

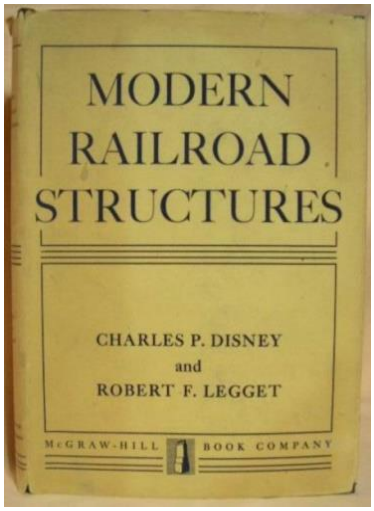
The diversity of Legget's articles during the period 1947 to 1969 is shown by the following examples:

- "Engineering Geology—a Fifty Year Review" was published in 1955 in *Economic Geology*, the 50th Anniversary Volume. Legget was invited to write this review, in part, because he was the author of *Geology and Engineering* in 1939.
- "The New Aklavik—Search for the Site" was published in 1960 in the *Engineering Journal.* Legget, a co-author with C.L Merrill and J. Pihlainen, was intimately involved in finding and proving the feasibility of what is now known as Inuvik.[17] Legget often mentioned that this was one of his most rewarding projects.
- "Failure of Prestressed Concrete Pipe at Regina, Saskatchewan" was published in the 1962 *Proceedings of the [UK] Institution of Civil Engineers*. Legget was awarded the ICE's Frederick Palmer Prize for this paper.
- "Geology in the Service of Man" was published in 1963 as a chapter in the 75th Anniversary Volume of the Geological Society of America, titled *The Fabric of Geology*.
- "The Metric System" was published by the DBR as *Canadian Building Digest* (CBD) #100 in 1968. Legget wrote it to help prepare Canadians and Canadian industry for the change to metric. In it, he wrote, "It is not inappropriate that this should be the hundredth issue of the Canadian Building Digest, since the essence of the metric system is dependence upon multiples of ten for all its subdivision." [18]

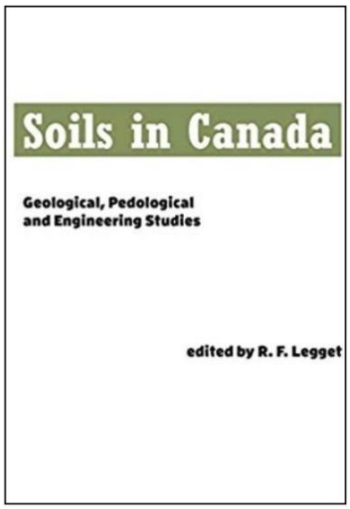
Legget's most unusual publication from his DBR years was titled "Noise Surveys of Cocktail Parties," co-authored with his DBR colleague T.D. Northwood. This peer-reviewed paper was published in 1960 in the *Journal of the Acoustical Society of America*.[19]

While Director of the DBR, Legget also authored, co-authored, edited (or co-edited) and revised several books.

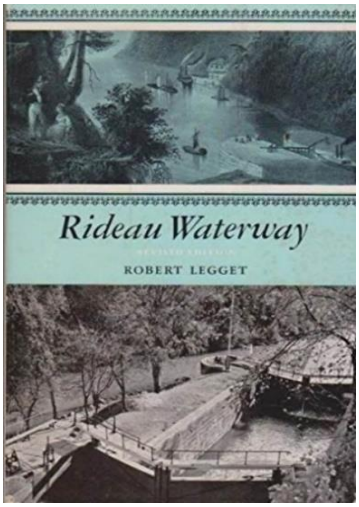
- *Modern Railroad Structures*, co-authored by Legget and published in 1949 by McGraw-Hill, 213 pages. Legget was the second author with US engineer Charles P. Disney.[20]
- *Rideau Waterway*, authored by Legget and published in 1955 by the University of Toronto Press, 320 pages.[21]
- *Soils in Canada—Geological, Pedological, and Engineering Studies*, edited by Legget and published in 1961 by the University of Toronto Press, 240 pages. It was revised in 1965[22]
- *Reviews in Engineering Geology, Volume I*, co-edited with US engineering geologist T.W. Fluhr and published in 1962 by the Geological Society of America, 286 pages.[23]
- *Geology and Engineering* 2nd edition, revised and updated by Legget and published by McGraw-Hill in 1962, 884 pages. Legget started thinking about this 2nd edition in 1953. He rewrote the first four chapters, revised nine others and added four new chapters. This edition was 235 pages longer than the 1st edition. From 1962 to 1980 it sold over 18,000 copies.



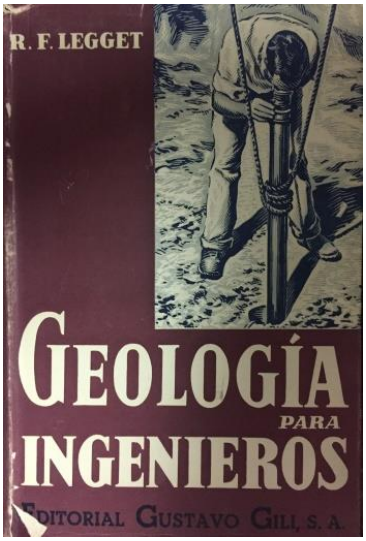
Modern Railway Structures 1949



Soils in Canada 1961



Cover of the revised edition 1972



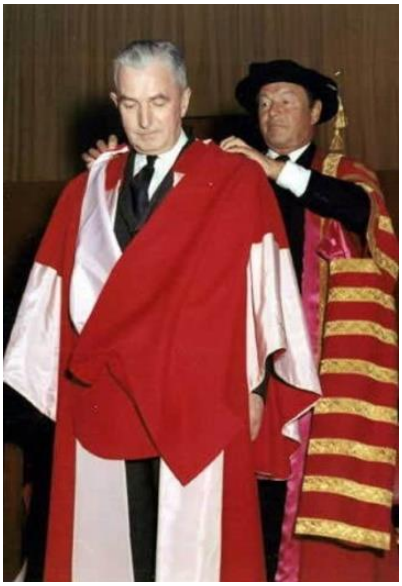
Spanish translation of *Geology and Engineering*[24] 2nd edition 1964. From a geological or engineering viewpoint it is not clear what the man on the cover is doing.

.

From 1952 until a few years after he retired as director, Legget also worked on another textbook on foundation engineering. He didn't get too far with this project and nothing was ever published. In the early 1960s, Legget also began work on a short non-technical book titled *To Be a Freshman*, on advice to undergraduate students. He laid it aside at the time, resurrected it in 1980, but left it unfinished.

During his time as director, Legget was honoured by several organizations including the Royal Architectural Institute of Canada, the Royal Society of Canada, the Engineering Institute of Canada, the Geological Society of America and the American Society of Testing Materials.[25]

Between 1961 and the year Legget retired from the DBR, he received honorary degrees from seven universities: McMaster University, the University of Waterloo, Queen's University, the University of Western Ontario (now Western University), the University of Toronto, the University of New Brunswick and Charles University in Prague, Czechoslovakia.[26] The latter three he received in one year, 1969.



Left: recipients of honorary degrees, Queen's University, Spring 1966. Legget is second from left in the front row.
Right: Legget receiving his LLD from the University of New Brunswick, 1969
(photo sources Queen's University and University of New Brunswick)

From the *Queen's Review*, May-June 1966:

> LLD—Robert Ferguson Legget, born on the Mersey but fated to become the intemperate lover of the Rideau, fellow of the Royal Society of Canada and of the Geological Society of America, teacher of civil engineers, consultant to industry, director of building research for the National Research Council since 1947; in each of these capacities a builder of Canada whose expert understanding of firm foundations is to be cherished in a shakily constructed country about to build its second century.

Legget's most prestigious honour during this period was to be appointed an Officer of the Order of Canada in 1967. This was the inaugural year of this honour, it being established to mark Canada's centenary. According to the Governor General's website, recipients have to have "enriched the lives of others and made a difference to the country." Later in Legget's life he would nominate other Canadians for this honour.

Legget receiving his Officer of the Order of Canada from Governor General Roland Michener in 1967 (NRC Archives)

Referring to the above photo, Legget was no stranger to formal photographs. Ten years earlier, in 1957, he sat for a photographic portrait by Yousuf Karsh: sitting #11464, January 24, 1957.[27] It is not clear why Legget was photographed by Karsh, although two individuals Legget greatly admired had portraits taken by Karsh—University of Toronto colleague C.R. Young in 1949, the sitting being sponsored by the U of T Engineering Alumni Association, and NRC Acting-President C.J. Mackenzie in 1940 and 1942, with no sponsor. Legget's photograph was not sponsored, meaning he had to pay for it himself. The cost is not known.

Legget was obviously well regarded by his colleagues, both within the DBR and the NRC, and throughout Canada. As further evidence of the latter, twice in the late 1950s he was approached to leave his position as Director of the DBR for other positions. In 1958, he was approached to replace the Dean of Engineering at the University of British Columbia, Henry Gunning.[28] In 1960, Legget was offered the position of Chairman of the National Capital Commission[29] by the Canadian Minister of Public Works, David Walker. Legget declined both offers.

Legget's portrait by Yousuf Karsh, 1957. Legget was 52 years old. (LAC Karsh Collection, used with permission)

Legget's son, David, was 13 when the family moved to Ottawa and left home in his later teens. He thought highly of his father, but they did not always see eye to eye, especially during David's teen years. His father was very strict and a stickler for good manners, dress and punctuality.[30]

Looking back, David recalls that he had a "damned good father" and "someone I'm proud to have known." He remembers, as a young boy, occasionally accompanying his father to lectures in the Ottawa area. David would be responsible for changing his father's "lantern slides" during the presentations. David still admires how well his father spoke and could engage his audience, no matter the topic.

During the period he was director, Legget and his family continued to spend parts of most summers on Grand Manan Island.

Legget retired from the DBR and the NRC in September 1969, the month of his 65th birthday. At that time in Canada, 65 years was the mandatory retirement age. On the evening that the NRC arranged to celebrate his retirement, Mary Legget was presented with 22 roses (one for each year of Legget being director) and Legget was presented with a gold watch, a photographic record of the "Legget Years", which was compiled and bound by his staff, and a leather-bound volume of letters contributed by 175 friends and colleagues from around the world.

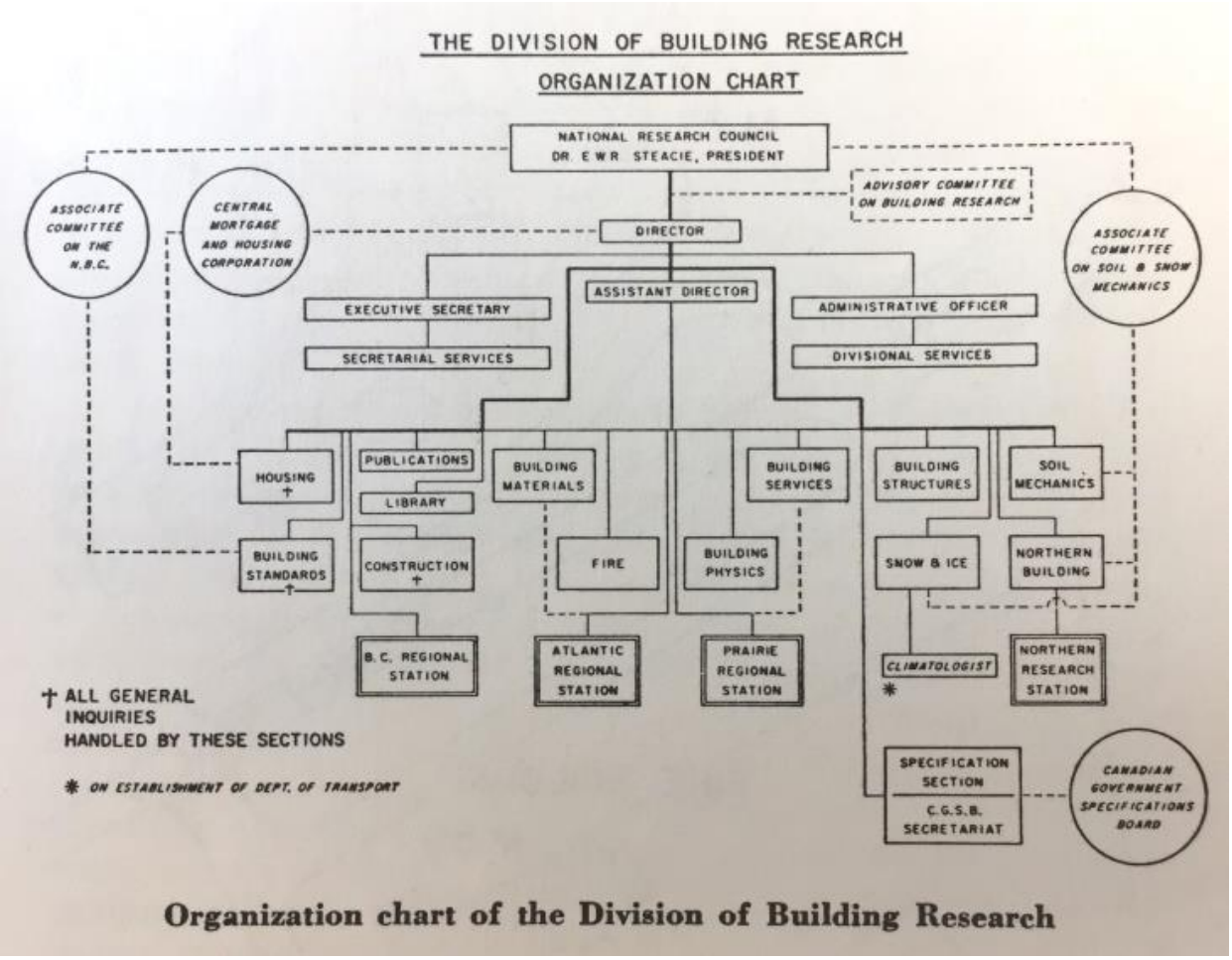
Legget receiving his leather-bound volume of letters from 175 friends and colleagues.
Presented by N.B Hutcheon, Legget's successor as Director of the DBR. (NRC Archives)

Legget, however, would not retire in the normal sense of the word. Far from it. He had another 25 years to live and he would make the most of them.

Annotations Chapter 16: DIVISION OF BUILDING RESEARCH YEARS (1947-1969)

[1] NRC documents indicate that Legget's "Date of commencement … with NRC," was June 2, 1947 (NRC Archives).

[2] The following figure is an organizational chart of the DBR in the late 1950s or early 1960s. Although the organization evolved somewhat over the years, the figure presents a picture of what Legget developed over his first decade as director.



Organization chart of the Division of Building Research

From an undated NRC publication, likely published in the late 1950s/early 1960s (LAC 20-10)

The Associate Committee on Soil and Snow Mechanics and the Soil Mechanics, Snow & Ice and Northern Building sections are shown on the extreme right of the chart. Other technical sections, from left to right, include Housing (and the Central Mortgage and Housing Corporation), Building Standards (and the Associate Committee on the National Building Code), Construction, Building Materials, Fire, Building Physics, Building Services, Specifications (and the Canadian Government Specification Board) and Building Structures. In addition, there were three "regional stations" listed from left to right: British Columbia, Atlantic and Prairie, and the Northern Research Station.

Non-technical departments on the chart include the Library, Publications, Secretarial Services and Administration, which included Drafting and Photography, Personnel and Travel, Supply and Office, Shop Services and Building Services. The latter non-technical department was added after the "Building Research Centre" was opened in October 1953.

[3] Hutcheon is introduced in Chapter 15 and its annotations.

[4] As related by Mike Bozozuk.

[5] Friends of the Pleistocene is an informal group of (predominantly) geologists who are interested in the Pleistocene Epoch, the period of geological time between 2.5 million years and 10,000 years ago, during which recent glaciation occurred. It was founded in 1934 in the northeast US and has organized field trips in the northeast US and eastern Canada almost annually ever since (Friends of the Pleistocene website).

[6] Organizations which Legget was a member of and contributed to in 1957 were (from *Ten Years of Building Research in Canada: 1947-1957,* NRC/DBR):

- American Society for Testing Materials (ASTM), general representative of the NRC
- Canadian Construction Association, a member on four committees: Business and Contractor Relations; Housing; Management and Research and Education
- Canadian Standards Association (CSA), a member of the Board of Directors and the Technical Council
- Geological Society of America, a member of the Council (he helped organize its Engineering Geology Division in 1947)
- International Union of Testing and Research Laboratories for Materials and Testing, a Canadian co-representative (with Hutcheon), and
- (UK) Institution of Civil Engineers, the Councillor representing Canada.

[7] The CIB is introduced in Chapter 14 and its annotations.

[8] The proceedings of this conference and all ISSMGE conferences are available on the ISSMGE website (see Chapter 24).

[9] Terzaghi had consulted extensively for BC Hydro and designed the Mission Dam in the early 1950s. Construction started in 1955 and the reservoir was first filled in 1960 (BC Hydro website).

[10] With financial assistance from the Canadian Foundation for Geotechnique, this tour has continued. There are currently two tours a year: one with a Canadian lecturer and the other with an international lecturer. See also *Geotechnical News*, March 2017 (CGS website).

[11] The Rapides-des-Quinze Hydroelectric Power project began with a single dam in the early 1900s and three more dams were constructed in the late 1940s/early 1950s.

[12] G.H. Klein is introduced in Chapter 15 and its annotations.

[13] The Nazis first invaded Prague in March 1939. Legget's unpublished document is titled "Czechoslovakia: 20-24 August 1968" (LAC 8-32).

[14] A listing of Legget's geotechnical and geological publications are listed in Chapter 23.

[15] The *Canadian Consulting Engineer*, a magazine for professional engineers involved with the construction industry, was first published in 1960.

[16] The titles of almost all of Legget's 108 "Historical Notes" are listed in Chapter 23.

[17] Established in the 1950s, Inuvik provided a resettlement location for the largely Inuit population of Aklavik. Aklavik, located centrally in the Mackenzie River delta was being threaten by flooding, erosion, thawing permafrost conditions and access issues.

[18] Canadian conversion to the metric system started in 1970 and continued through the 1970s but has never been completed or fully embraced by the country (or Canadians of a certain age!).

[19] The following is the abstract from the paper by Legget and T.D. Northwood titled "Noise Surveys of Cocktail Parties:"

> This paper discusses and enlarges on a recent theoretical paper by W.R. MacLean on the acoustics of cocktail parties. The discussion is supported by experimental evidence accumulated during the past two years. MacLean's analysis suggests that there is a critical density of participants above which a "quiet" cocktail party becomes abruptly "noisy." It would appear that one might actually plan a quiet or noisy party as required (assuming control over the number of participants).

Unfortunately, the cases studied experimentally do not show this quiet-noisy transition, and it is believed that factors not considered in the theory result in a blurring of the distinction. Indications are that there is a gradual increase in sound level to a saturation value that is independent of the properties of the room, the beverages served, and the number of participants. There is, however, dependence on the sex of the participants.

[20] *Modern Railway Structures* was an illustrated record of some of the advances in the design and construction of the more important structures required for railroads, such as grading, bridges, masonry walls and turntables. The text was mostly on types of bridges. Charles Disney (no relation to Walt) was an American railroad engineer who, in 1934, wrote *New Developments in Grade Separation Structures*. He died in Baltimore, MD in 1950. How Legget and Disney met is not known.

[21] Legget "discovered" the Rideau Canal when he was teaching at Queen's University—Kingston being at the southern end of the canal. He started researching the history of the canal in 1943 when he was teaching at U of T. As mentioned earlier, Legget's home on Echo Drive in Ottawa overlooked the Rideau Canal.

[22] Legget also wrote the preface and introduction to *Soils in Canada* and co-wrote with Robert Hardy a paper on the "Engineering Significance of Soils in Canada."

[23] There are now 22 volumes in this Geological Society of America series.

[24]The Spanish translation is *Geology for Engineers*.

[25] Legget's honours during this period included:

- 1953: Honorary Fellow of the Royal Architectural Institute of Canada
- 1959: Fellow of the Royal Society of Canada
- 1960: Honorary Member of the Ontario Association of Architects
- 1965: Fellow of the Engineering Institute of Canada. Fittingly, this was same year that Robert Hardy was also made an EIC Fellow. They were the first two Canadian geotechnical engineers to be so recognized.
- 1965: Fellow of the Geological Society of America; Legget served as President of the GSA the following year.
- 1967: Foreign Fellow of the Geological Society of London
- 1968: Honorary Member of the Canadian Construction Association, and
- 1968: Honorary Member of the American Society of Testing Materials, Committee D-18 on Soil and Rock for Engineering Purposes. Legget joined this committee in 1940.

[26] The honorary degrees Legget received between 1961 and 1969 were:

- 1961: LLD (Doctor of Laws) from McMaster University
- 1963: DSc (Doctor of Science) from the University of Waterloo
- 1966: LLD from Queen's University, Kingston
- 1969: DSc from the University of Western Ontario (now Western University)
- 1969: LLD from the University of Toronto
- 1969: LLD from the University of New Brunswick, and
- 1969: DGS (Doctor of Geological Sciences) from Charles University, Prague, Czechoslovakia (now the Czech Republic).

Legget receiving his honorary Doctor of Geological Sciences from Charles University in 1969 (LAC Spec Coll)

[27] Yousuf Karsh (1908-2002), an Armenian-Canadian and long-time Ottawa resident, was one of the greatest portrait photographers of the 20th century. Notable subjects included Winston Churchill (1941), George Bernard Shaw (1943), Dwight Eisenhower (1946), Albert Einstein (1948), Audrey Hepburn (1956), Ernest Hemingway (1957) and Nikita Khrushchev (1963).

[28] Henry Gunning served as UBC Dean of Engineering from 1954 to 1959. He resigned to become a consulting geologist for the Anglo-American Corporation in Africa. The position, offered to Legget, was filled by David M. Myers, Head of the Department of Electrical Engineering at the University of Sydney, Australia (UBC Website).

[29] The National Capital Commission is a federal Crown corporation created in 1959 “to ensure that Canada’s Capital is a dynamic and inspiring source of pride for all Canadians and a legacy for generations to come.” Its predecessors were the Ottawa Improvement Commission, created in 1899, and the Federal District Commission, created in 1927. Legget would have replaced Major General Howard Kennedy as Chairman. Alan Hay filled the position that Legget declined (NCC website).

[30] David became a reporter for the *Carleton Place Canadian*—Carleton Place is approximately 50 km southwest of Ottawa—and then eventually a photojournalist for the *Montreal Star*. He married and had two children. In his early 30s, David became disenchanted with the newspaper business and with his father’s assistance he returned to school as a mature student, obtained a teaching degree and became a successful music teacher in the Toronto public school system. David and his wife still live in Toronto (David Legget, personal communication).

[Chapter 17:] L'ENVOI[1]

It will have been very obvious to any reader who has managed to get this far that the simple request of Jack Clark and Dave Townsend opened up for me a Pandora's box of memories - so much so that I now feel that, perhaps, I have included too much of a personal nature about the early years, even though it seemed to be relevant in explaining how fortunate I was to be associated with the start of Geotechnique in Canada. This was no "inspiration" on my part but just my good fortune to be in the right place at the right time and to have been privileged to be aided by wonderful friends, as I hope I have made crystal clear. And it is of friends that I think as I close off this memoir, most of them still active, some who have passed on, leaving rewarding and treasured memories. For all these friendships, I am truly grateful.

Despite a few difficulties which I have not hesitated to record, it has been a wonderful experience. Were there any highlights? There were indeed...

...the first Soil Mechanics meeting in the Maritimes, at Fredericton in April 1954,[2] attracting twice as many as we had expected, including some very practical construction men who kept our feet on the ground, with the St. John River in flood and, despite this, the Premier of the Province (Hugh John Flemming[3]) coming to our luncheon and being really interested, so much so that he remembered the occasion in his final years when he had become a friend...

...the wonderful team work and team spirit that gradually developed among the whole Canadian geotechnical fraternity (a word I use with meaning and with pleasure), demonstrated in full measure when, as chairmen of the Organising Committee for the sixth International Conference in Montreal (the record of which I leave others to relate),[4] I had to leave for meetings in Europe just six weeks before the start of the great meeting; things probably went better with me away, but only Carl Crawford (probably) knew the depth of my concern, but he knows also the imperative of my being at the *[Conseil international du bâtiment]* meetings[5] that took me away, now from his own experience[6]...

...the evening on The Mountain *[Mount Royal]* in Montreal during the Conference when the Mayor[7] opened up part of his wonderful wine cellar for our buffet supper at the Lookout *[at the top of Mount Royal]* on that perfect summer evening, the moon coming up just as (at the Mayor's behest) all the lights suddenly came on in every tall building below us and a hush fell upon the crowd, a hush that told us that all our worries were over ("How do you Canadians arrange evenings like this?" is a query I still treasure!)...

...the dinner at the 1968 annual conference when I was asked to describe my experiences just a few weeks before when I had lived through the invasion of the lovely city of Prague by Soviet forces, at the start of the International Geological Congress;[8] never in my life have I felt such a glow of friendship and mutual concern as seemed to fill that crowded, hot room on that memorable evening...

...and, naturally, the annual dinner in Kingston in 1969 when my friends marked my retirement as Director of DBR/NRC and my earlier retirement as Chairman of ACGR, by announcing to my bewilderment the establishment of the first Canadian geotechnical award to which, in their kindness, they attached my name.[9]

My feelings about that recognition are still, today, far deeper than words can express and so all I shall allow myself to say in conclusion is that I hope I have done just a little to be worthy of that most gracious honour, that my appreciation of all that I have gained by being a member of the Canadian geotechnical team is at least indicated in part by what has gone into the writing of this memoir, and that the end is not yet; I still hope to be of some minor service.[10]

Annotations Chapter 17: L'ENVOI

[1] "L'envoi" is literally translated from the French as "the sending off." At the end of piece of writing it is used to indicate concluding remarks.

[2] It is not known to which "Soil Mechanics meeting" Legget is referring. The 8th Canadian Soil Mechanics (Geotechnical) Conference in 1954 was held in Ottawa in December of that year. The first Canadian Geotechnical Conference held in the Maritimes was the 13th conference, held in Halifax in 1959. The first Canadian Geotechnical Conference held in Fredericton was the 34th conference in 1981.

[3] John Hugh Flemming (1899-1982) was the 24th Premier of New Brunswick from 1952 to 1960. He later served as a federal Member of Parliament from 1960 to 1972 and served as minister in two portfolios in Prime Minister John Diefenbaker's Conservative cabinet (Wikipedia).

[4] The 6th International Conference on Soil Mechanics and Foundation Engineering was held in Montreal in 1965.

[5] In 1998, the name of the Conseil international du bâtiment was changed to the International Council for Research and Innovation in Building and Construction but the acronym, CIB, has remained in use. This organization was introduced and described in Chapter 14 and its annotations.

[6] In 1983, when Legget wrote his memoir, Carl Crawford was Director of the Division of Building Research and would have represented Canada on the CIB.

[7] The Mayor of Montreal in 1965 was Jean Drapeau, who served as mayor from 1954 to 1957 and from 1960 to 1986 (Wikipedia).

[8] The 21st Canadian Geotechnical Conference was held in Winnipeg in September 1968. Legget's attendance at the International Geological Congress in Prague in August 1968 is described in Chapter 16.

[9] It was during the annual dinner of the 22nd Canadian Geotechnical Conference held in Kingston, ON, that the idea of the Robert F. Legget Award was announced. The award was first presented in 1970 at the 23rd Canadian Geotechnical Conference held in Banff, AB. It was presented, posthumously, to Robert (Bob) Peterson.

The table below lists all the Robert F Legget Award and Medal recipients to 2019. The "award" was changed to a "medal" in 2000. Many of those listed have been mentioned in this book.

1970	R Peterson	1971	RM Hardy	1972	NW McLeod	1973	V Milligan
1974	GG Meyerhof	1975	CB Crawford	1976	AG Stermac	1977	P LaRochelle
1978	DH MacDonald	1979	NR Morgenstern	1980	RJE Brown	1981	B Ladanyi
1982	DJ Bazett	1983	JI Clark	1984	L Samson	1985	JI Adams
1986	MAJ Matich	1987	CF Ripley	1988	WA Trow	1989	KY Lo
1990	EJ Klohn	1991	RM Quigley	1992	JD Mollard	1993	RN Yong
1994	M Bozozuk	1995	FA Tavenas	1996	JL Seychuk	1997	GC McRostie
1998	DG Fredlund	1999	CO Brawner	2000	DH Shields	2001	J Graham
2002	RP Benson	2003	RK Rowe	2004	G Lefebvre	2005	J Krahn
2006	OL White	2007	S Lacasse	2008	JF Gartner	2009	DM Cruden
2010	DE Becker	2011	WDL Finn	2012	E McRoberts	2013	S Leroueil
2014	PM Byrne	2015	J Locat	2016	RJ Bathurst	2017	D Stead
2018	M Aubertin	2019	A Valsangkar				

[10] What Legget accomplished between the time he wrote his memoir in 1983 and when he died in 1994 is described in Chapter 20.

[Chapter 18:] APPENDICES

[Editor's note: The following three Appendices A, B and C are from Legget's 1983 memoir.

Appendix A: In his 1983 memoir, Legget inserted a poor quality photocopy of a reprint of his three-page August 1936 article in the Engineering Journal*. The article was published in a very small typeface. The Appendix A that follows is the same article, reformatted and presented in a larger font.]*

The First International Conference on Soil Mechanics and Foundation Engineering

Cambridge, Mass., June 22-26, 1936

(Abstract of a report contributed by R. F. Legget, A.M.E.I.C.)

The first International Conference on Soil Mechanics and Foundation Engineering, held at Harvard University, Cambridge, Mass., U.S.A., from June 22nd to 26th, 1936, was attended by about two hundred and fifty engineers and research workers, representing almost twenty different countries The conference assembled for the first time the results of soil research work at present proceeding in many parts of the world, and correlated at least to some extent the studies of soils necessitated in many of the various branches of civil engineering work.

The President of the conference was Dr. Karl von Terzaghi, of the Technische Hochschule in Vienna, Austria, and presently a visiting professor at Harvard University, to whom is due very largely the progress which has already been made in the scientific study of soils. In his addresses, Dr. Terzaghi sketched the development of what has now generally become known as the science of Soil Mechanics, using the word in its true geological sense, as denoting all unconsolidated materials found as constituents of the earth's crust. It was recalled that about twenty-five years ago, in three different countries, the attention of engineers was forcibly directed to close study of sands and clays by reason of certain disastrous failures. In America, the Panama canal slides; in Sweden, the severe slides on the state railroad system which resulted in the appointment of the Royal Swedish Geotechnical Commission of Landslides; and in Germany, the construction of the Kiel canal led to such serious difficulties that careful studies were necessarily initiated. The incidence of the war impeded progress, but in the years immediately prior to 1920 it was finally demonstrated that geological observation of such phenomena was not enough, and physical soil tests, planned in a general manner, were soon begun, although with primitive apparatus. Thereafter, soil research work commenced in many laboratories and universities throughout the world.

Studies of soil problems had been made from the start of modern engineering, and due tribute was paid to the many records of observed data in connection with such engineering works which are to be found in older engineering publications, especially those of Great Britain, dating up to the year 1880. Subsequently, empirical rules, based on these observations, seemed to become generally accepted and records gradually became more fragmentary. This condition persisted until more scientific study of soils began, when these older rules were often found wanting. Although at the start of recent investigations it had been hoped to develop a tool as definite as (say) structural analysis, such hopes had been abandoned, but gradually a new mass of evidence was being assembled, and on this foundation it was being found possible to erect the framework of a useful science.

Chairmen of national committees had been appointed prior to the conference, in addition to four vice-presidents, one Italian, one English, and two American, and the resulting preliminary work led to nineteen countries being represented at the proceedings. American engineers naturally predominated in number, but both Mexico and Germany sent relatively large delegations, and six engineers were present from Canada. Two engineers travelled to the conference from the Far

Section B. Exploration of Soil Conditions and Sampling Operations.

The eight papers in this section gave many useful references to standard types of sampling equipment, the development of which has been mainly the work of engineers who have had to adapt standard drilling methods so that, with little trouble or expense, relatively "undisturbed" samples of soils can be obtained from any desired depth, below ground level. The basic idea of all the main types of sampler is to drill first a fairly large diameter drill hole, case it if necessary, and then insert a special sampling tool which is forced into the ground at the bottom of the hole, rotated to isolate the core, and then withdrawn, the sample obtained being sealed, with either a part of the metal casing left in place, or with paraffin wax, to prevent change of moisture content, etc. The developments of this idea are generally designed to reduce the necessary disturbance to a minimum. Examples were given of the evident distortion, within the sampling tool, of various sizes of samples, due to the friction between the metal of the sampler and the soil. Examples were also given of the swelling of even small clay samples obtained from great depths. The use of "undisturbed" samples has been generally confined to those of clayey strata, cohesionless materials such as sands and gravels being usually tested by means of loose disturbed samples.

Section C. Regional Soil Studies for Engineering Purposes.

A group of six papers dealing with regional soil surveys demonstrated the extent to which soil studies have been applied to preliminary civil engineering work. Of special interest was a description of a complete soil survey of an area of 900 acres near New York, to be used initially for the 1939 World's Fair, and ultimately as a public park, but at present low lying marsh and swamp land. By means of extensive sampling and subsequent laboratory work, a complete knowledge of subsurface conditions has been obtained from which predictions regarding probable foundation settlements, data for foundation design, and methods for filling procedure have been worked out.

Section D. Soil Properties.

This section was concerned with general considerations presented in thirteen widely different papers. Work at present being carried out at the Building Research Station of the British Government on the shearing strength of clays, following up Professor Jenkin's initial studies of granular materials, was described by L. F. Cooling and D. B. Smith, the former amplifying the paper in discussion by demonstrating the utility of the shear strength of clays at zero normal load as a means of obtaining the constant in the basic shear equation. Research work carried out in France on the effect of the speed of loading on soil properties was described in another paper. The important influence of the chemical nature of clays on their physical and mechanical properties was demonstrated in a paper by K. Endell and U. Hoffman (Germany). This fundamental aspect of the subject was reflected in a paper describing Russian research work on the influence of scale-like particles (such as mica) on soil properties.

In general discussion, little attention was devoted to the properties of granular materials (sands and gravels) as there appears to be general agreement on at least their main characteristics. With regard to clays and cohesive soils, it was generally admitted that research on the shear strength of such materials is still incomplete.

Section E. Stress Distribution in Soils.

This branch of study is complicated by the fact that although theoretical analyses can be made of stress distribution in homogeneous

A portion of the first page of Legget's 1936 paper in the *Engineering Journal*

Appendix A: From the *ENGINEERING JOURNAL*, August 1936, pp 389-391

The First International Conference on Soil Mechanics and Foundation Engineering

Cambridge, Mass., June 22-26, 1936

(Abstract of a report contributed by R. F. Legget, A.M.E.LC.)

The first International Conference on Soil Mechanics and Foundation Engineering, held at Harvard University, Cambridge, Mass., U.S.A., from June 22nd to 26th, 1936, was attended by about two hundred and fifty engineers and research workers, representing almost twenty different countries. The conference assembled for the first time the results of soil research work at present proceeding in many parts of the world, and correlated at least to some extent the studies of soils necessitated in many of the various branches of civil engineering work.

The President of the conference was Dr. Karl von Terzaghi, of the Technische Hochschule in Vienna, Austria, and presently a visiting professor at Harvard University, to whom is due very largely the progress which has already been made in the scientific study of soils. In his addresses, Dr. Terzaghi sketched the development of what has now generally become known as the science of Soil Mechanics using the word in its true geological sense, as denoting all unconsolidated materials found as constituents of the earth's crust. It was recalled that about twenty-five years ago, in three different countries, the attention of engineers was forcibly directed to close study of sands and clays by reason of certain disastrous failures. In America, the Panama canal slides; in Sweden, the severe slides on the state railroad system which resulted in the appointment of the Royal Swedish Geotechnical Commission of Landslides; and in Germany, the construction of the Kiel canal led to such serious difficulties that careful studies were necessarily initiated. The incidence of the war impeded progress, but in the years immediately prior to 1920 it was finally demonstrated that geological observation of such phenomena was not enough, and physical soil tests, planned in a general manner, were soon begun, although with primitive apparatus. Thereafter, soil research work commenced in many laboratories and universities throughout the world.

Studies of soil problems had been made from the start of modern engineering, and due tribute was paid to the many records of observed data in connection with such engineering works which are to be found in older engineering publications, especially those of Great Britain, dating up to the year 1880. Subsequently, empirical rules, based on these observations, seemed to become generally accepted and records gradually became more fragmentary. This condition persisted until more scientific study of soils began, when these older rules were often found wanting. Although at the start of recent investigations it had been hoped to develop a tool as definite as (say) structural analysis, such hopes had been

abandoned, but gradually a new mass of evidence was being assembled, and on this foundation it was being found possible to erect the framework of a useful science.

Chairmen of national committees had been appointed prior to the conference, in addition to four vice-presidents, one Italian, one English, and two American, and the resulting preliminary work led to nineteen countries being represented at the proceedings. American engineers naturally predominated in number, but both Mexico and Germany sent relatively large delegations, and six engineers were present from Canada. Two engineers travelled to the conference from the East Indies, one from Java, and the other from the Federated Malay States. A member of the staff of the Building Research Station of the British Government represented recent British research work.

The free interchange of ideas between engineers of so many nations, both in formal discussion and outside the conference rooms, was perhaps the most notable feature of the conference. Eight half-day technical sessions were held, each starting with either one or two illustrated lectures on engineering work in one of half a dozen countries.

The papers submitted to the conference number over one hundred and fifty. All were printed either in full or in abstract form and distributed to participating members prior to the opening session. A volume, to be issued later in the year, will contain a record of the proceedings and will present an invaluable collection of data of actual records from construction, and of theoretical analysis.

Contributions were classified under fifteen sections, to which reference is made in the following notes.

Section A. Reports from Soil Mechanics Laboratories.

Twenty-five papers were presented, describing the equipment and research work of twenty soil mechanics laboratories in America, Europe, and Japan. Members of the conference were enabled, in the evening sessions, to visit the soil mechanics laboratories of Harvard University and of the Massachusetts Institute of Technology, seeing there several of the types of testing equipment described in the papers. Humid rooms to assist in the correct determination of moisture content of clays etc., are a standard feature of the larger laboratories. Grain size is usually determined by means of standard sieves and the hydrometer method developed by *[Arthur]* Casagrande. Compression, consolidation and permeability are mechanical properties the study of which is now almost standardized. Several different methods were described for the testing of the fourth fundamental mechanical property of soils and their shear strength.

Section B. Exploration of Soil Conditions and Sampling Operations.

The eight papers in this section gave many useful references to standard types of sampling equipment, the development of which has been mainly the work of engineers who have had to adapt standard drilling methods so that, with little trouble or expense, relatively "undisturbed" samples of soils can be obtained from any desired depth, below ground level. The basic idea of all the main types of sampler is to drill first a fairly large diameter drill hole, case it if necessary, and

then insert a special sampling tool which is forced into the ground at the bottom of the hole, rotated to isolate the core, and then withdrawn, the sample obtained being sealed, with either a part of the metal casing left in place, or with paraffin wax, to prevent change of moisture content, etc. The developments of this idea are generally designed to reduce the necessary disturbance to a minimum. Examples were given of the evident distortion, within the sampling tool, of various sizes of samples, due to the friction between the metal of the sampler and the soil. Examples were also given of the swelling of even small clay samples obtained from great depths. The use of "undisturbed" samples has been generally confined to those of clayey strata, cohesionless materials such as sands and gravels being usually tested by means of loose disturbed samples.

Section C. Regional Soil Studies for Engineering Purposes.

A group of six papers dealing with regional soil surveys demonstrated the extent to which soil studies have been applied to preliminary civil engineering work. Of special interest was a description of a complete soil survey of an area of 900 acres near New York, to be used initially for the 1939 World's Fair, and ultimately as a public park, but at present low-lying marsh and swamp land. By means of extensive sampling and subsequent laboratory work, a complete knowledge of subsurface conditions has been obtained from which predictions regarding probable foundation settlements, data for foundation design, and methods for filling procedure have been worked out.

Section D. Soil Properties.

This section was concerned with general considerations presented in thirteen widely different papers. Work at present being carried out at the Building Research Station of the British Government on the shearing strength of clays, following up Professor Jenkin's initial studies of granular materials, was described by L. F. Cooling and D. B. Smith, the former amplifying the paper in discussion by demonstrating the utility of the shear strength of clays at zero normal load as a means of obtaining the constant in the basic shear equation. Research work carried out in France on the effect of the speed of loading on soil properties was described in another paper. The important influence of the chemical nature of clays on their physical and mechanical properties was demonstrated in a paper by K. Endell and U. Hoffman (Germany). This fundamental aspect of the subject was reflected in a paper describing Russian research work on the influence of scale-like particles (such as mica) on soil properties.

In general discussion, little attention was devoted to the properties of granular materials (sands and gravels) as there appears to be general agreement on at least their main characteristics. With regard to clays and cohesive soils, it was generally admitted that research on the shear strength of such materials is still incomplete.

Section E. Stress Distribution in Soils.

This branch of study is complicated by the fact that although theoretical analyses can be made of stress distribution in homogeneous materials, soils as encountered in practice are always far from uniform. The classical theory of Boussinesq therefore formed the basis of much of the analytical presentation and in some of the eleven papers included in this section, was in sharp

contrast with records obtained from actual observations. Of special interest to practising engineers is a paper (E9, by G.M. Rapp and A.H. Baker) describing the measurement of soil pressures on the lining of the new mid-town tunnel under the Hudson river, at present under construction in New York, in which details of the gauges used are given and a summary of the records so far obtained.

Section F. Settlement of Structures.

In this section, the explanation of and the predetermination of the settlement of structures attracted much attention. Fifteen papers were presented, many of these being actual records of settlement, and one of the illustrated lectures was given by Dr. Hanna and Mr. [Tschebotarioff], amplifying data they had given in papers regarding the settlement of structures in Cairo, Egypt. The poor subsoil conditions there encountered were contrasted with the underground formation of volcanic ash and fine sand found at Mexico City, which in the past has caused serious settlement of many large buildings there. Other papers gave data on settlements from Shanghai, Vienna, and Texas, as well as from three American bridges. One of the latter was the new bridge over the Mississippi river at New Orleans, which had to be founded on unconsolidated strata over 2,000 feet thick. Subsurface exploration was very carefully carried out and settlement calculations made in connection with all pier design; these were checked as construction of the piers proceeded, and as a result, certain valuable modifications were introduced into the completed bridge design. An interesting observation made was that during flood period on the river, with a rise of water level of 15 feet, a temporary settlement of one and a half inches took place, which disappeared on resumption of normal water level.

In discussion it was stressed that the main purpose of settlement studies is to enable foundations to be so designed that settlements can be predicted with a fair degree of accuracy. Small scale loading tests may be potentially dangerous unless carefully correlated with other test data, and with records of the geological formation at the building site. Theoretical considerations are beginning to take definite shape, but they must be checked by actual observation. There is need for the collection by engineers of all possible settlement records.

Section G. Stability of Earth and Foundation Works and of Natural Slopes.

There were nine papers in this section, a number of these being theoretical analyses based on the idea of a cylindrical sliding surface, first developed by Petersen of Sweden. Some valuable data on actual slips on the Whangpoo river of China were given in a paper by Wang Chen. Another notable contribution was a review of Indian research work on uplift pressures under weirs presented by the Irrigation Research Institute of the Punjab. Stability calculations for the important closure section of the Fort Peck dam (U.S.A.) were outlined, and in another paper the importance of ground water tension was emphasized and details of research work were given.

Section H. Bearing Capacity of Piles.

Section I. Pile Loading Tests.

These two subjects are closely linked, at least in the minds of engineers, although during discussion the necessity for a distinction between the two was emphasized. Six papers had been

submitted in each of the two sections, and contained valuable practical data. In discussion details were given of the results of driving over ten thousand bearing piles in Nebraska, records of all of which had been carefully analysed. Several of the papers were of Dutch origin including a description of an experimental device for determining the necessary length of bearing piles and the toe resistances, developed by the Soil Mechanics Laboratory at Delft. Professor P. E. Raes of Belgium presented an interesting theory of the lateral bearing capacity of piles.

The dangers which may be created by driving piles into certain types of clay and the ambiguous meaning of the term "the safe bearing power" of a pile were brought out in discussion.

One of the papers outlined the requirements for piled foundations in the newly formulated Building Code for the city of Boston, drafted by a joint committee of engineers and research soil workers. A leading feature of the code is the abandonment of the usual static type of pile formula and its replacement by a dynamic formula.

Section J. Earth Pressure Against Retaining Walls.

This important subject did not attract the attention which might have been expected, only six papers being submitted. These, however, included three new contributions from Dr. Terzaghi, to some extent supplementing his previous outstanding work in this field. One of these papers, "A fundamental fallacy in earth pressure computations" (reprinted from the Journal of the Boston Society of Civil Engineers) was an illuminating review of the assumptions inherent in the Rankine and Coulomb formulae, and a demonstration of the fact that the normal pressure distribution due to granular soils is not hydrostatic in nature, the application of Coulomb's formula being limited to the case where the lateral yield of the wall exceeds certain minimum values. Another paper, from the Iowa Engineering Experimental station, presented the results of some interesting tests on the normal pressures on retaining walls due to concentrated surface loads.

Section K. Ground Water Movement and Seepage.

Three papers only were submitted in this section, two from the University of Bandoeng, Java (Mr. Steevens, one of the authors, attending the meetings) describing work being carried out on the electrical investigation of underground water flow nets. The subject was naturally mentioned in the several descriptions of earth dams presented to the conference, and research work at Harvard University was seen in progress in which dyes were used to indicate underground flow (similar to Indian work).

Section L. Soil Problems in Highway Engineering including Frost Action in Soils.

This important application of soil studies bears on such problems as the design and construction of embankments, the control of natural slopes, the survey and design of subgrades, and the design of stabilized soil road surfaces. Intensive study of frost action in soils now proceeding at Harvard University was described, and an important illustrated lecture on the same subject was given by Dr. Breskau, of Sweden, who has been a pioneer in this branch of study. Standard methods of soil survey as practised in the states of New Hampshire, Michigan and Texas were described, and mention was also made of the standard soil classification and standard soil

grouping adopted for these and other purposes by the United States Bureau of Public Roads.

At the end of the conference a special two-day excursion was arranged for those delegates specially interested in highway work, during which modern American practice was inspected. An interesting lecture by Dr. Wm. Loos of Germany described the many different methods tried in Germany for the consolidation of newly placed fill material, in attempting to obtain stable subgrades in a short space of time for the new motor highways now being constructed in that country.

Section M. Methods for Improving the Physical Properties of Soils for Engineering Purposes.

In this essentially practical section, four papers described examples of soil consolidation. A newly developed electro-chemical method, invented by [Leo] Casagrande, was described in a paper from Germany, the basic idea of the method being the passage of direct current electricity through clays between aluminum anodes and copper cathodes. Tests which are described in the paper suggested that the method has great possibilities. In one of the illustrated lectures Mr. G. Rodio of Milan, Italy (whose firm were responsible for the underpinning of the leaning Tower of Pisa), described a remarkable example of chemical consolidation in the completion of the foundation for the building "La Basilese Vita" in Lugano.

Section N. Modern Methods of Design and Construction of Foundations.

In the nine papers of this section, in the introduction and discussion by Lazarus White of New York, and in two outstanding illustrated lectures, many interesting foundation methods were described. As one example there may be mentioned the use of a reinforced concrete rigid frame basement for the new Telephone building in Albany, N.Y., where unequal settlement could not be avoided but could be predetermined. Further work in Mexico City was described and also an unusual foundation study by American engineers for the Palace of the Soviets in Moscow, Russia. One of the two lectures, by C.S. Proctor of New York, described briefly the foundation work necessary for the San Francisco-Oakland bridge across San Francisco Bay now approaching completion. The other lecture was by A.E. Bretting of Copenhagen and described some of the foundation work for modern bridges in Denmark, one being the Sorstrom bridge, the soil studies for which were described in a paper submitted by Mr. Bretting. The foundation work was notable for the use of an elliptical floating steel caisson which was used as a ring support for steel sheet piling, being floated away for use on other piers when one pier had been completed up to ten feet below water level.

Section Z. Miscellaneous.

Some of the papers submitted could not be classified in the regular sections. Among these may be noted one entitled "Practical Soil Mechanics at Muskingum" (a reprint of four articles in the Engineering News Record issues of March 26th, April 9th, 23rd and May 7th *[1936]*). This communication dealt with the application of soil mechanics studies to the design and construction of an extensive programme of flood control works on the Muskingum river, involving the construction of fourteen earth dams of different sizes and on sites of varying compositions.

Thorough study of all soils available for use at each site has obviated the need for the use of older empirical methods of design. A point of special interest in this contribution is the presentation of detailed costs of all soil studies and equipment, the total operating and construction cost of the project soils laboratory up to the end of the design period being $32,000. Core borings and test pits cost $225,000 and $12,000 was spent on geological studies, making a total of $269,000 for preliminary work, which may be compared with the estimated total cost of $40,000,000 for the fourteen reservoirs included in the project.

A film of the construction of the Fort Peck dam was shown, in connection with papers on the extensive soil studies carried out on this project, which when completed will be the largest hydraulic-fill dam in the world.

A lecture was given by Dr. A. Agatz of Germany on the construction of harbour works at Bremen and at Bremerhafen [sic], dealing with the investigations of sheet pile wharf walls which had been made in connection with this important harbour development. Another lecturer gave a description of the start of construction of the new dams for the water supply of the Metropolitan District of Boston, the last day of the conference being devoted to a visit to these works, located about eighty miles west of Boston. The two dams are hydraulic-fill structures designed to form the Quabbin storage reservoir, each being located in a valley filled with glacial drift necessitating the use of rectangular concrete caissons to form the necessary cut-off walls. Material adjacent to the site is being used for dam construction in each case, and extensive soil studies have developed striking features of design and construction which were well seen when the two dams were visited by those attending the conference.

Conclusion.

On Friday, June 26th, the conference met for its closing dinner and valedictory speeches at the Wayside Inn, Sudbury, Mass., made famous by Longfellow, and now carefully preserved by Henry Ford. With its old-world air, the inn is a relic of the past in a country that is still called new and seemed a fitting meeting place for a conference which marked the public recognition of a new science.

The evident enthusiasm of all participants and the efficient preliminary secretarial work made the success of the conference certain. Any doubts which may have existed as to the reality of the science of Soil Mechanics were finally dispelled for all who were privileged to attend, while the records of the conference will furnish a similar assurance to all engineers who study them.

On the other hand, the discussions indicated that there still exists an appreciable gap between the scientist, carrying out laboratory research into the properties of soils, and the practising engineer who has to use those materials. For example, some research workers stated that, at present, no accurate knowledge as to the shear strength of clays could really be obtained, whereas this is a property on which some reliance must be placed daily by engineers in construction. The geological aspects of soil studies were not often mentioned: they, too, will probably play a greater part in future development. Discussions also showed that the science is still in an early stage of

development, and is not the finished product some of its more enthusiastic advocates might seem to suggest. The proceedings clearly indicated the need for a more extensive interchange of experience and ideas between engineers of different countries to avoid duplication of effort and to enable the best use to be made of records obtained from practice. For this reason the decision to continue the conference in some permanent form, to be decided upon later, was welcomed. The words used by Mr. Schmitt, the Editor of Engineering News-Record, sounded a fitting keynote for such future action—"a science is evolving; an art is being revolutionized."

Appendix B: The Associate Committee; an Outside View.

Extract from a paper by Dr. N.B. Hutcheon, when Director, Division of Building Research, National Research Council, "on Geotechnical Research in Canada," presented to the "Seminar on Guidelines for Scientific Activities in Northern Canada" 1972, held at Mont Gabriel, Quebec, and published in *Science and the North*, Information Canada, Ottawa 1973.

p 232:

> A decision was made at the time the Division of Building Research was created to continue the war-time studies of terrain problems under the direction of an associate committee of the National Research Council. This associate committee, now known as the Associate Committee on Geotechnical Research, recognized four main subject areas of interest, namely, soil mechanics, snow and ice mechanics, organic terrain, and permafrost, and served these interests for many years through four active subcommittees. The study of permafrost and the promotion of an understanding of it has been the special objective over the years of the Subcommittee on Permafrost of the Associate Committee on Geotechnical Research.
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> In a report to that Subcommittee made by Harwood and Brown in October 1968,[1] it was noted that there were only five full-time research workers on permafrost problems in the federal government. In addition, there were up to fifteen academics and students interested in these problems and perhaps five consultants having competence in terrain engineering. This is not much national capability to support a multi-billion dollar construction program.
>
> More recently another subcommittee, on Pipeline and Land Use Technology in Northern Terrain, has been established. The deliberations of this new subcommittee led to the organisation of a Canadian Northern Pipeline Research Conference, attended by more than five hundred delegates, in February 1972.
>
> The success of these ventures has been remarkable, and constitutes an outstanding example of the way in which government, industry, university, and professional engineering research and associated interests can be encouraged and made highly inter-active with great mutual benefit. As a consequence, there is now a closely-knit, highly responsive group of geotechnical specialists in Canada who are well-informed and sensitive to developing needs. Links between people, agencies, and information sources at home and abroad are already highly developed and Canada is in a position to make the very best of what under other conditions might well be a disastrously inadequate response to the current needs for northern terrain engineering. It is highly significant that the Associate Committee on Geotechnical Research is a national interdisciplinary committee providing a balanced representation in its membership of industry, universities and government. It has been particularly effective in promoting the core of engineering expertise which has now become

of vital importance. Although sponsored by the National Research Council, which is a government agency, it is essentially non-governmental, having no responsibilities in day-to-day operations of government."

Appendix C: A Note on Early Workers in Canada

Although I have never made a special search for records of early geotechnical work in Canada, my diggings into the history of civil engineering in this country have turned up some notable pioneers and some remarkable early work. This is "out of my province" but as a help to those who will be looking into this part of the History of Geotechnique, the following references may be useful:

Sir Sandford Fleming: two papers by F.L. Peckover and me will be found in the *[Canadian Geotechnical] Journal*, Vol 10 for 1973 recording quite the most remarkable early work known to me.[2]

Samuel Fortier: an almost unknown pioneer who used soil compaction before R.J. Proctor was born; see *[Canadian Consulting Engineer]* December 1970.[3]

Joseph Hobson: another of the unknowns, builder of the Sarnia CNR tunnel (test borings every 20 ft); see CCE September 1979 and March 1982.[4]

The building of the Murray Canal near the end of last century involved some remarkable test borings work; CCE January 1980.[5] So also did the studies, by the Dept. of Public Works, for the Georgian Bay Ship Canal in the first decade of this century; see Sessional Paper No. 10 of the House of Commons, 1909.[6]

Professor Barnes, of McGill University, was a somewhat unconventional pioneer in Ice Research; I think he wrote a book on his work (1920?).[7]

Prof. E. Brown of McGill and C.G. Clark had a paper in the *Engineering Journal* in the late 1920s or early 1930s on their experiments with ice in a cold storage warehouse[8]...and there may be others!

Annotations Chapter 18: APPENDICES

[1] Actually Hutcheon was referring to the 1969 publication by T.A. Harwood and R.J.E. Brown, "A Report on Permafrost, Part III," in *Report on the Geotechnical Sciences to the Solid-Earth Science Study Group of the Science Council of Canada*, National Research Council, Associate Committee on Geotechnical Research, TM 95, 17 p plus appendices.

[2] Legget, R.F. and Peckover, F.L. 1973. "Foundation Performance of a 100-year-old Bridge," *Canadian Geotechnical Journal*, Vol 10, pp 504-519 and
Peckover, F.L. and Legget, R.F. 1973. "Canadian Soil Penetration Tests of 1892., *Canadian Geotechnical Journal*, Vol 10, pp 528-531.

[3] Legget, R.F. 1970. "Dr. Samuel Fortier pioneered basics of soil mechanics," *Canadian Consulting Engineer*, December.

[4] Legget, R.F. 1979. "CNR Tunnel under St. Clair River still in use," *Canadian Consulting Engineer*, September. and
Legget, R.F. 1982. "Joseph Hobson—another name to add to our list of engineering greats," *Canadian Consulting Engineer*, March.

[5] Legget, R.F. 1980. "Sub-surface conditions determine route of Ontario's Murray Canal," *Canadian Consulting Engineer*, January.

[6] This publication is actually Sessional Paper 19A.

[7] Howard Turner (1873-1950) obtained a bachelor's degree in physics (1893), a master's degree in applied science (1896) and a DSc (1900), all from McGill University. He taught and did research at McGill from 1900 to 1933. Turner wrote two books on ice: *Ice Formation, with Special Reference to Anchor-ice and Frazil* (1906) and *Ice Engineering* (1928) (Wikipedia).

[8] E. Brown and Clark, G.S. 1932. "Ice Thrust in Connection with Hydro-Electric Plant Design (with Special Reference to the Plant at Island Falls on the Churchill River, Saskatchewan)," *Engineering Journal*, Vol 15, pp 18-??.

[Chapter 19:] SUPPLEMENT TO *GEOTECHNIQUE IN CANADA*

[Editor's note: Robert Legget wrote and submitted this "supplement" to his March 1983 memoir in May the same year. He suggested that it be placed part way through what is now part of Chapter 7 (Canada Pre-Conference (1929-1936)). It is, however, really is a side-bar to the story while Legget was working with Canadian Sheet Piling (1932-1936) and therefore it has been given this separate chapter.]

An even larger installation of Larssen steel sheet piling was for the construction of a new wharf at Rimouski, Quebec, in the Gulf of St. Lawrence. This major development involved the building in the open sea of a wharf 700 ft long and 100 ft wide of high strength steel piling and extensive dredging. The project was designed in the office of the District Engineer at Rimouski for the Department of Public Works Canada, Louis-Georges Trudeau.

Responsible for the excellent site investigation, and all aspects of design was one of his young assistant engineers, Jean Paul Carrière, another of the pioneers of géotechnique in Canada. He was self-trained, not having had the privilege of a University education, but to such good effect that he was (I believe) the first engineer to be admitted to the Corporation of Professional Engineers of Quebec[1] by writing and passing all their examinations after finding that they did not recognize the certificate he had won from the International Correspondence Schools.

The design (which I checked) was straightforward; the contract drawings admirably produced. Good tenders were anticipated and were in due course received in open bidding. There was, however, one tender from a previously unheard of firm which was so ludicrously low that the principals of the firm had to be called in for consultation.

It was then found that the firm *[that made the low bid]* had been specially formed for this job by a local entrepreneur, teamed up with a small Ottawa contractor who had some construction equipment. When the absurd nature of the bid was explained, the head of the firm brushed this aside by saying that "he had friends in Ottawa who would take care of him" if he lost money (as he was bound to do).

Even when the rigorous administration of a Department, initiated by Deputy Minister J.B. Hunter (a wonderful part of the story of civil engineering in Canada—all tenders, for example, being opened in public by Mr. Hunter himself as long as he was Deputy Minister, the award always going to the low bidder) was explained, this was also pooh-poohed. And so the contract had to be awarded to this unusual firm.[A]

They did, eventually, finish the job but at the expense of untold worry on the part of DPW engineers, and with manifold delays. Jean Paul Carrière kept meticulous records, since he knew

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[A] Carrière, J.P. 1939. "Steel Sheet Pile Wharf at Rimouski, Quebec," [US] *Civil Engineering*), Vol 9, pp 707-710.

that there would be "trouble" of some sort after the job was over. There was indeed. The firm entered a vast claim for extras against the Department but the days of political wire-pulling over such matters had long since gone, so they got nothing. They then went to Court and the case was heard, in Rimouski, before Mr. Justice Angers of the Exchequer (now Federal) Court of Canada. I was privileged to be asked to be an "expert witness" for the Government of Canada.

It proved to be a fascinating experience but I must refrain from going into detail. Suffice to say that, although the firm had not "got a leg to stand on," so to speak, they were able to engage as their counsel the Honourable Thomas Viens, a member of the Senate of Canada. To begin with, this brilliant man had no "papers" (since the firm did not even keep good records) but in Court he gradually wormed these out of the Department. Once he had these, he saw that he had no technical grounds for winning his case; he therefore turned to legal aspects and, on a legal technicality which the Government's lawyer missed, he won a judgement for the contractors.

This was really a reflection on the counsel for the Government, a Mâitre Bienvenu (later a Judge who died tragically in Hull). *[Bienvenu]* was a brilliant criminal lawyer—during the course of the trial I watched him, with fascination, make one of the contractor's witnesses perjure himself in the course of half an hour!—but he was no match for the legal brilliance of Viens. There was consternation at the verdict and so the Government immediately appealed it to the Supreme Court of Canada, with a Mr. Louis St. Laurent of Quebec City as their new counsel.[2] It took the High Court about five minutes to throw out the verdict and so the contractor got nothing.

I mention this case since, although the judgements were all related to legal aspects of the job, and not to the geotechnical, it was one of the first major geotechnical cases to come before the Canadian courts. And it introduces into this record Jean Paul Carrière. He went on to be the District Engineer, DPW, at London, Ontario, leaving this position in 1939 to assume his military duties when war broke out, since he had always been active in the Militia (in the Royal Canadian Engineers).

By the end of the war, he was Chief Engineer of the Canadian Army in France, and eventually a Brigadier, being given a number of prestigious military awards. While still a Colonel, he had commanded the group of Royal Canadian Engineers who made a name for themselves by constructing a bypass road around the lovely town of Leatherhead, Surrey,[3] in a matter of months—to the amazement of British engineers and contractors who came from all over the United Kingdom to see how "the Canadians" did it. After the war, he held three positions briefly until he found the right "niche" as President of Franki Pile Co. of Canada,[4] a position he still held when he died in 1978. He also served as first President (part-time) of the Standards Council of Canada.

He comes in to another early geotechnical project, also unfortunately omitted from my original memoir. I mentioned the origin of my book on *Geology and Engineering*, the first edition of which was published by the McGraw-Hill Book Co, in 1939.

When studying landslide literature for writing the landslide chapter, I was fortunate enough

to procure an original copy of the famous 1912 Report of the special Committee of the (US) National *[Academy of Sciences]* on the Panama Canal Slides, a fascinating volume, and still a treasured possession.[5] In a small footnote to one of the Appendices, printed in the smallest type possible, I found a reference to a *[Parisian]* French publication on Landslides dated 1846, the author being A. Collin. I was sure that the date must be a mistake but further study showed that it was not, although I could not find any trace of a copy of the book.

This was while I was *[a lecturer]* at Queen's University.[6] One of my pleasures there was to meet Dean S.C. Hollister of Cornell University,[7] through Prof. Lindsay Malcolm,[8] to whose friendship I later pay tribute. Dean Hollister was interested in the history of engineering and told us of a great plan he had for publishing, through Cornell, a series of volumes containing the great "classics" of early engineering. When I told him about the Collin book he was fascinated and urged me to try to find a copy and get it translated.

Accordingly, I continued my search, eventually writing to the Canadian Embassy in Paris asking for their help. They kindly located an original copy in the Bibliothèque Nationale in Paris. So I wrote to this great Library and ordered a photocopy but my letter to them was mailed (*[I was now in]* Toronto[9]) two or three days before the Germans entered Paris.[10] So all seemed lost. I reported this to Hollister who shared my regret. But as he was walking home, after reading my letter, he recalled that Cornell University has one of the finest collections of French literature in North America. So, taking a long shot, he went and consulted the Librarian in charge of the French collection. And they, too, had an original copy of Collin's book![11] So Dean Hollister had a microfilm copy made for me...but the war made any work on it quite impossible.

When, however, the fighting in Europe was over, Jean *[Paul]* Carrière (who knew about the Collin book) had time on his hands during the demobilisation operation which he had to oversee, and so he suggested that the two of us, by correspondence, might start the job of translating. This we did but we did not get very far before J.P.C. returned to Canada, and I moved up to Ottawa.[12] So work stopped again! But I did not forget that precious microfilm.

When visiting the British Building Research Station (in 1951), I happened to notice on *[Leonard]* Cooling's[13] desk in their Soil Mechanics Section, a mimeographed paper by A.W. Skempton[14] with the name Collin on it. When I asked Skempton about this, and told him that I had a copy of the original book, he was naturally interested, urging me to "get busy" and have it translated.

After my return to Ottawa, I spoke with W.R. (Bill) Schriever, who had now joined the Division *[of Building Research],* to our pleasure and benefit, and he agreed to have a shot at the translation, starting this work (I think) while resident in Toronto on the Subway job.[15] It was a difficult task since the book was (naturally) written in old French, with extremely long paragraphs. Upon Bill's return to Ottawa, the two of us used to spend a short time at the end of every working day going through the literal translation (which he had prepared) and converting it into readable English.

When this job was done, we investigated publishing possibilities and the result was the fine volume published by the University of Toronto in 1956, with a prefatory memoir on Collin's life by A.W. Skempton.[B] [16] The volume was soon sold out, an early Canadian contribution to international Geotechnique.

[B] Schriever, W.R. (translator) 1954. *Landslides in Clays by Alexandre Collin, 1846,* University of Toronto Press, 160 p with plates.

Annotations Chapter 19: SUPPLEMENT TO GEOTECHNIQUE IN CANADA

[1] Now the Ordre des ingénieurs du Québec (OIQ).

[2] Louis St. Laurent (1882-1973) subsequently became the 12th Prime Minister of Canada (1948-1957), preceded by WL Mackenzie King and succeeded by John Diefenbaker (Wikipedia).

[3] Leatherhead is approximately 30 km southwest of London.

[4] Franki piles were developed in the early 1900s by Belgian engineer Edgard Frankignoul. The method, still widely used, is used to install cast-in-place concrete piles with an expanded base (Wikipedia). Franki piles are sometimes referred to as “compacto piles” or “expanded base piles or footings.”

[5] The National Academy of Sciences document to which Legget refers is “Report of the Committee of the NAS on Panama Canal Slides,” Memoirs Vol 18, published in 1924.

Legget had a fascination with canals. Sir William Smith, the “Father of British Geology” (1769-1839) and a civil engineer, was noted for his work on the canals of England in the late 1700s. Legget refers to Smith in a number of his publications and includes Smith’s photograph as a frontispiece in his 1939 textbook *Geology and Engineering*. Legget wrote two books on canals: the 320-page *Rideau Waterway* (1955) and 261-page *Canals of Canada* (1976). In 1989 he treated himself to a cruise through the Panama Canal. The last paper Legget had published (1993) was on the Panama Canal. It was published in the *Canadian Geotechnical Journal.*

[6] As described in his memoir, Legget was a lecturer at Queen’s University from 1936 to 1938.

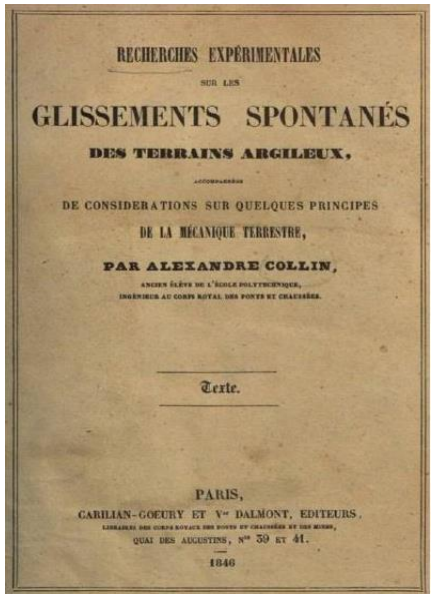
[7] Cornell University in Ithaca, New York, is approximately 300 km south of Queen’s University in Kingston.

[8] Professor Lindsay Malcolm is introduced in Chapter 10 and its annotations.

[9] Legget moved from Queen’s University to the University of Toronto in 1938.

[10] Paris fell to Nazi Germany on June 14, 1940.

[11] The cover of Collin’s 1846 book.


RECHERCHES EXPÉRIMENTALES
SUR LES
GLISSEMENTS SPONTANÉS
DES TERRAINS ARGILEUX,
DE CONSIDERATIONS SUR QUELQUES PRINCIPES
DE LA MÉCANIQUE TERRESTRE,
PAR ALEXANDRE COLLIN,
Texte.
PARIS,
CARILIAN-GOEURY ET Vve DALMONT, EDITEURS,
QUAI DES AUGUSTINS, Nos 39 ET 41.
1846

Collin, A. 1846. *Recherches Expérimentales sur les Glissements Spontanés des Terrains Argileux, Accompangées de Considerations sur Quelques Principes de la Méchanique Terrestre,* Carilian-Goeury and Dalmont, Paris.

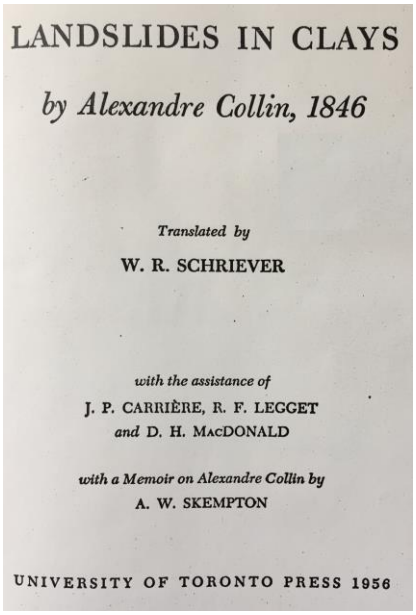
[12] Legget moved to Ottawa in 1947 to become the founding Director of the National Research Council’s Division of Building Research. See Chapters 14 and 15.

[13] L.F. Cooling is introduced in Chapter 8 and its annotations.

[14] Sir Alec W. Skempton (1914-2001) was an English civil engineer and, along with Karl Terzaghi, is considered one of the pioneers of soil mechanics. He established the soil mechanics program at Imperial College, London. He is also noted for his contributions to the history of civil engineering. He was knighted in 2000 (Wikipedia),

[15] Bill Schriever was a Swiss engineer who worked for the NRC/DBR on the construction of the Toronto subway in the early 1950s. He is introduced in Chapter 12 and its annotations.

[16] Photo of the title page of *Landslides in Clays*.


LANDSLIDES IN CLAYS

by Alexandre Collin, 1846

Translated by

W. R. SCHRIEVER

with the assistance of

J. P. CARRIÈRE, R. F. LEGGET

and D. H. MACDONALD

with a Memoir on Alexandre Collin by

A. W. SKEMPTON

UNIVERSITY OF TORONTO PRESS 1956

"Translated by W.R. Schriever with the assistance of J.P. Carrière, R.F. Legget and D.H. MacDonald, with a Memoir on Alexandre Collin by A.W. Skempton." D.H. (Don) MacDonald was a student of Legget's at the University of Toronto who, along with Bill Schriever, worked on the Toronto subway in the early 1950s.

Chapter 20: "RETIREMENT" YEARS (1969-1994)

The end of Robert Legget's 1983 memoir generally coincides with his retiring as Director of the National Research Council's Division of Building Research (DBR) in 1969. This chapter summarizes what he did during his 25 years of "retirement." The word "retirement" is in quotes because, as will become evident, Legget did not "retire" in typical fashion.

In retirement, in addition to continuing his writing, Legget gave numerous lectures, did some consulting, attended conferences and meetings and travelled with his wife Mary. He continued to participate in many organizations, helped form some new ones and received numerous awards and honours.

The chapter is divided into four time periods: 1970-1976, 1977-1984, 1985-1992 and Legget's final 16 months in 1993 and 1994.

1970-1976

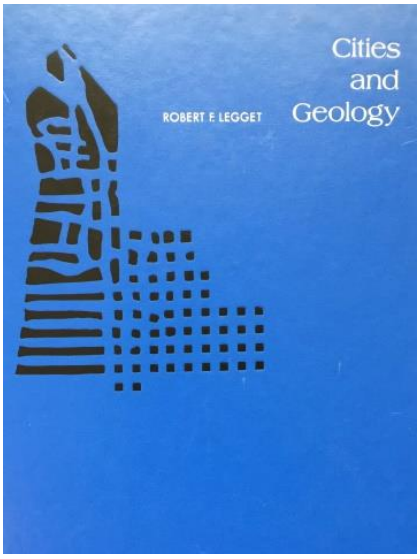
When Legget retired, he maintained a few professional commitments including:

- Overseeing the completion of the 1970, 5th edition of the *National Building Code of Canada*.
- Writing a review of Canadian standards for the Economic and Science Councils of Canada. This 274-page report was published by the Government of Canada in 1971 as *Standards in Canada*.
- Being the General Editor of the Canadian Building Series, published by the University of Toronto Press. This commitment began in 1967 and included overseeing the publication of approximately one major publication a year. He continued in this role until 1978.

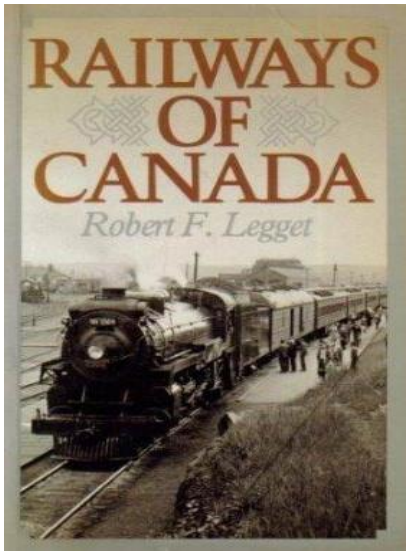
Along with these commitments, Legget's priority was to research and write two books on totally different subjects. Both were published in 1973. The first book was the 624-page *Cities and Geology*, published by McGraw-Hill.[1] It was very well received and awarded prizes from both the Geological Society of America and the Association of Engineering Geologists for best publication of the year. Over 6,000 copies were sold before it went out of print in 1980. The second book was the 255-page *Railways of Canada* published by David & Charles. In addition, in 1972 Legget published a revised edition of *Rideau Waterway*, originally published in 1955.

These books were soon followed by two others: the 304-page *Ottawa Waterway, Gateway to a Continent*, published by University of Toronto Press in 1975 and the 261-page *Canals of Canada* published by David & Charles in 1976. Legget's life-long passions for railways and canals were coming to the fore.

Between 1970 and 1976, in addition to books, Legget wrote almost 40 peer-reviewed articles and numerous shorter articles, conference papers, report introductions, book reviews, discussions and news items. Approximately 35% of these were related to geology and geotechnique,[2] 20% to building construction, standards, codes and fire protection, 15% to engineering in society and education, 15% to railways and 10% to engineering history.



Cities and Geology 1973



Railways of Canada 1973

Legget continued as the anonymous Canadian correspondent for the *Engineering News-Record* and contributed 40 more "Historical Notes" to the *Canadian Consulting Engineer.* He also started to contribute "Historical Geological Notes" to a new publication of the Geological Association of Canada called *Geoscience Canada*. Six of these notes were published between 1973 and 1983.[3]

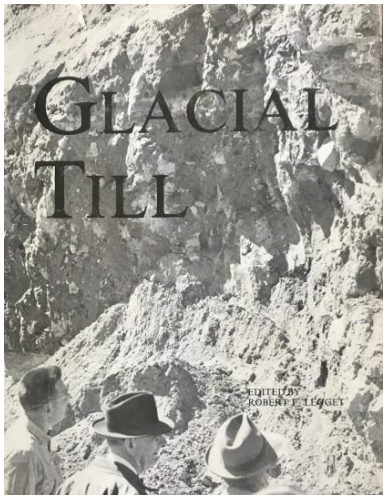
The following demonstrate the diversity of Legget's writing during this period:

- "The Profession of Engineering—Its Challenge for the Future," published in 1970 in the *Engineering Journal.*
- *Committees—Working Guide*, a small booklet prepared for and published by the National Research Council in 1971 that included chapters on "The Gentle Art of Chairmanship" and how to run a meeting, among other topics.
- "Controlling Fires in Tall Buildings," published in (US) *Civil Engineering* in 1971.
- "Early Maps in Current City Development," a paper published in the 1972 *Proceedings* of the 6th Conference of the Association of Canadian Map Libraries.
- "Early Ice Experiments at Davos [Switzerland]: J.C. McConnel (1890-1890)," a paper published in a 1974 issue of the *Journal of Glaciation*.
- "Do Engineers Read (or Buy) Books," published in a 1976 issue of *Scholarly Publishing.*
- "The Underground of Cities," a paper published in the 1975 *Proceedings of the Symposium on the Development and Utilization of Underground Space*, Kansas City, MO.

The last example was the first article that Legget published on underground space, a new area of interest for him and an area that he would devote more time over the next several years.

During this period, Legget kept his close ties with the DBR and many of his publications relating to geotechnique and buildings were reprinted as DBR technical papers or technical notes.

Legget also co-edited the proceedings of the 1972 Canadian Northern Pipeline Research Conference and edited the 1976, 412-page Royal Society of Canada Special Publication titled *Glacial Till; an interdisciplinary study*.



Dust Jacket of *Glacial Till* 1976. The cover photo was taken by Legget on a “Friends of the Pleistocene” field trip.

Between 1970 and 1976, Legget travelled extensively. Some was just for his and his wife’s pleasure. On one such trip they travelled on the *MS Havelland*, a Great Lakes freighter, from Montreal up the St. Lawrence Seaway, across Lake Ontario, up the Niagara River, through the Welland Canal and across Lake Erie to Detroit.[4]

Other personal trips were a return visit to Czechoslovakia, a trip to Bratislava and a holiday on the French islands of St. Pierre and Miquelon, off the coast of Newfoundland. And to round out their travels, the Leggets continued to spend a portion of most years on Grand Manan Island in the Bay of Fundy.

MS Havelland in 1961 (photo source City of Vancouver Archives, CVA 447-4965.3, Walter E. Frost photographer)

Most of Legget’s travel during this period, however, was for work and Mary frequently accompanied him. For two years he was an adjunct professor at the University of Minnesota. Between 1970 and 1976, Legget gave lectures at 16 other US universities and at 14 Canadian universities.

Consulting projects that involved travel included acting as an expert witness for the Mackenzie Valley Pipeline Inquiry (also known as the Berger Inquiry), conducting an evaluation

of the doctoral programs in civil engineering in Ontario universities and undertaking a review of the Ontario Science Centre in Toronto. This last assignment was for his former colleague, Tuzo Wilson, then director of the centre.

Legget also travelled to accept awards and honours, including ones from the Engineering Institute of Canada (EIC), the Geological Association of Canada, the Association of Professional Engineers of Ontario, the Canadian Council of Professional Engineers (now Engineers Canada), the American Society for Testing Materials (ASTM), the Association of Engineering Geologists and the Geological Society of Belgium.[5] Legget was the first recipient of the honours he received from the Association of Professional Engineers of Ontario and the Canadian Council of Professional Engineers.

Legget (right) receiving the ASTM Walter C. Voss Award in 1970 (LAC Spec Coll)

In addition to the seven honorary degrees that he was awarded while Director of the DBR, Legget was awarded his remaining six honorary degrees during this period. These were from the University of Glasgow, the University of Liverpool, Thomas S. Clarkson College of Technology (now Clarkson University) in Potsdam, NY, Sir George William University (now part of Concordia University) in Montreal, the Technical University of Nova Scotia (now part of Dalhousie University) in Halifax, NS, and Carleton University in Ottawa.[6]

It must have been particularly satisfying for Legget to be awarded his long sought-after DEng by his *alma mater,* the University of Liverpool. In 1971, shortly after receiving this degree, Legget represented the University of Liverpool at the investiture of the University of Toronto’s Chancellor, Paula McGibbon, who replaced Legget’s former NRC colleague, Omond Solandt, in that position.

Between 1970 and 1976, Legget remained a member of many organizations. He also joined the Canadian Geotechnical Society (CGS)[7] and the Historical Association of Ottawa.

As Legget mentions in Chapter 17, in 1970, the Geotechnical Engineering Division of the Engineering Institute of Canada, from which the CGS evolved, recognized Legget’s retirement from the DBR and his many contributions to Canadian geotechnique by establishing the Robert

F. Legget Award. This was the first award established in Canada to recognize achievements in Canadian geotechnique. Today, after awarding 50 deserving individuals, the Canadian Geotechnical Society's Robert F. Legget Medal (as it was renamed in 2000) is still the most prestigious geotechnical award in Canada.[8]

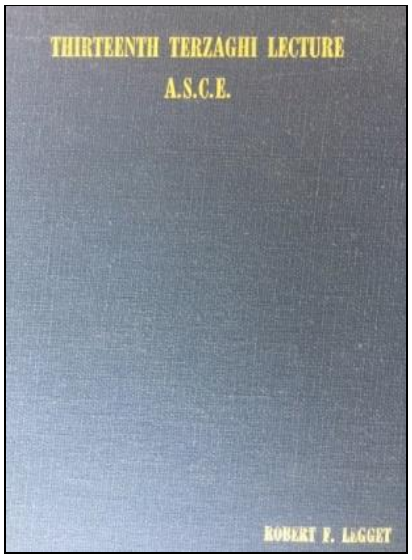
It is not known why, but, in 1974, Legget became a founding member of the Arbitrators Institute of Canada Inc, a professional body associated with dispute resolution.

1977-1984

For Legget, who turned 73 in 1977, this period started off with a bang. In March 1977, he presented the inaugural Sandford Fleming Foundation lecture at the University of Waterloo. His topic was "Sandford Fleming, Pioneer Engineer." Fleming was a Canadian pioneer engineer for whom Legget had great respect and admiration.[9] In the same month, Legget gave a special lecture at the University of Toronto to help celebrate its sesquicentennial. His aptly selected topic was "The First Hundred and Fifty Years of Civil Engineering in Canada."

In September, he attended conferences in Sweden (Rockstore 77) and Czechoslovakia (Landslides and Other Mass Movements). The following month he attended the American Society of Civil Engineers' annual conference in San Francisco.

In San Francisco, Legget presented the prestigious Terzaghi Lecture, the thirteenth such lecture. For professional and personal reasons, he considered this experience the technical highlight of his career. The topic, a passion for most of his career, was "Geology and Geotechnical Engineering." His presentation was published in 1979 as a 50-page paper in the American Society of Civil Engineers' *Journal of the Geotechnical Engineering Division*. Legget was very proud of this paper and had several copies bound. He presented one to Ruth Terzaghi, Karl Terzaghi's widow.

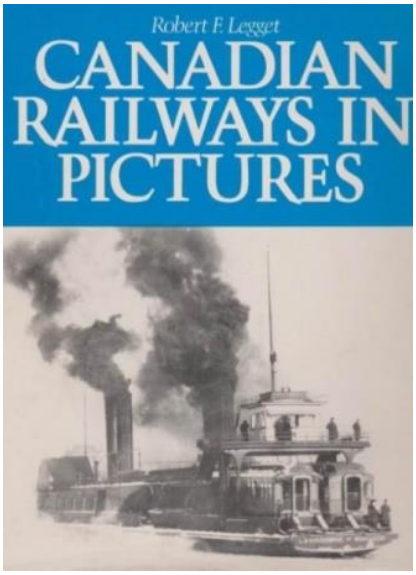


Legget's bound copy of his Thirteenth Terzaghi Lecture given in 1977 and published in 1979

At the same San Francisco conference, Legget was also made an honorary member of the ASCE. This honour was one of three he received that year, the others being the Engineering

Institute of Canada's most prestigious Sir John Kennedy Medal and the inaugural William Smith Medal from the Geological Society of London.[10]

Sometime during 1977 Legget published another book on railways, the 96-page *Canadian Railways in Pictures*, this time by Douglas, David & Charles Publishers. In his spare time that year, he started an outline of an autobiography that he didn't finish; however, he incorporated some of that outline in his 1983 memoir.



Canadian Railways in Pictures 1977

Later in this same period, Legget's late-developing interest in underground space culminated with his editing the 131-page *Geology Under Cities*, published in 1982 as Volume 5 of the Geological Society of America series "Reviews in Engineering."

One of Legget's major projects between 1977 and 1984 was writing a handbook of geology for civil engineers. In the early 1970s, McGraw-Hill Publishers had the idea of publishing a series of "handbooks" for professionals. These were to be larger than textbooks and intended to sit on professionals' bookshelves as reference books. In 1971, because of his past publications with McGraw-Hill, the publisher approached Legget to write the *Handbook of Geology in Civil Engineering*. Now in his late 60s, he invited Paul Karrow to be a co-author. Karrow, a Quaternary geologist and 26 years Legget's junior, was a Professor in the Department of Earth and Environmental Sciences at the University of Waterloo.[11]

Little was done on the handbook until 1980 and then, over the next three years, both Legget and Karrow put a great deal of time and effort into the project. The handbook used Legget's 1962 2nd edition of *Geology and Engineering* as a starting point, but also incorporated portions of Legget's 1973 *Cities and Geology*, which by 1980 was out of print and not slated for reprinting by McGraw-Hill.

The handbook contained several entirely new topics such as rock mechanics, underground space and problem soils. Many chapters of Legget's 2nd edition were expanded. As McGraw-Hill wished, this handbook was larger than a textbook. It was 1,340 pages and included 771 illustrations. It weighed almost two kilograms and sold for $94.50.[12] This was the first

engineering book that Legget wrote for which he did not do his own indexing.

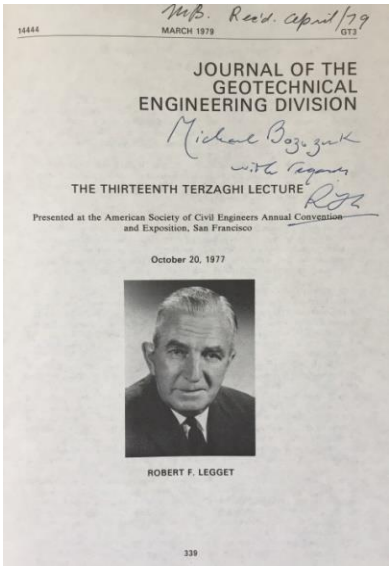
The handbook was published early in 1983; however, it was not received as well as the earlier editions of *Geology and Engineering*. Reviewers felt it was not up to date with the newer developments in either geology or civil engineering. Negative reviews were foreign and a blow to Legget but they did not slow him down. In the same year that the handbook was published, he started plans for a 3rd edition of his textbook *Geology and Engineering*.

Between 1977 and 1984, Legget also wrote almost 30 papers, numerous shorter articles, conference papers, report introductions, book reviews, discussions, short notes and news items. Approximately 25% of these were related to geology and geotechnique, 25% to engineering history, 20% to underground space, 15% to engineering in society and education, 10% to buildings and 5% to railways. He also wrote one article on an older interest of his, conservation.

Examples of his contributions during this period are:

- "Building and Working Underground Saves Energy," published in 1977 in *Canadian Geographic*.
- "Geological Observations of Alexander Mackenzie on the First Crossing of North America in 1793," published in 1978 in *Musk*-Ox.[13]
- "75-Year-Old Underground Compressed Air Plant Still in Use in Canada," published in 1979 in *Underground Space*.
- "Logan and Landslides: 1842," published in 1979 in the *Canadian Geotechnical Journal*.
- "Glacial Geology of Grand Manan Island New Brunswick," published in 1980 in the *Canadian Journal of Earth Sciences*.
- "Canadian General Standards Board: The First Thirty Years," published in 1984 in the *Canadian General Standards Board Quarterly*.

As was common at that time, once an article was published, Legget would give or send reprints of that article to his friends and colleagues.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JOURNAL OF THE GEOTECHNICAL ENGINEERING DIVISION

Michael Bozozuk with Regards

THE THIRTEENTH TERZAGHI LECTURE

Presented at the American Society of Civil Engineers Annual Convention and Exposition, San Francisco

October 20, 1977

ROBERT F. LEGGET

339

Legget's reprint of his Thirteenth Terzaghi Lecture paper given to colleague Michael Bozozuk

In the same time period, Legget also contributed 20 more "Historical Notes" to the

Canadian Consulting Engineer. He continued to be the anonymous Canadian correspondent for the *Engineering News-Record* until the November 24, 1983 issue.[14] It was exactly 50 years prior, in early December 1933, that Legget submitted his first contribution to the *EN-R*. Was his timing to stop contributing just a coincidence?

Legget did not publish everything he wrote. After the *Handbook of Geology in Civil Engineering* was published in early 1983, he turned his attention to writing *Geotechnique in Canada, a Personal Memoir*, the memoir on which this book is based.[15] He based it somewhat on the autobiography that he outlined in 1977 and somewhat on an unpublished piece he wrote in 1979, titled "Fifty Years in Canada".[16]

Legget so much enjoyed the process of recalling and writing about his career and past contributions to the profession that, upon completion of the 1983 geotechnical memoir, he wrote a similar unpublished memoir, *Standards in Canada, a Personal Memoir*. He put on the cover of this 34-page manuscript "Private and Confidential." It is not known how widely this memoir was distributed.[17]

In 1984, at Sir William Halcrow & Partners' request, Legget wrote a short unpublished paper on his involvement with and the people at C.S. Meik and Buchanan, the consulting firm he worked with between 1925 and 1929. As described in Chapter 7, he met his wife Mary while working there and Legget indicated on the title page of his 1984 paper that he was "assisted by Mrs. 'Mary' Legget, née Miss Lilian S. Free."[18]

Between 1978 and 1986, Legget also worked on an outline for another book titled *Geology and Man*. It was never written.[19]

Legget continued his lecturing during this period. His more significant lectures were the 35th Bownocker Memorial Lecture at the School of Earth Sciences at Ohio State University in 1978 and two lectures associated with the 125th anniversary of engineering at the University of New Brunswick. The UNB lectures were on "Canadian Engineering Achievements" and "The Canadian Engineer's Responsibility to Society: Past and Future."

Legget also continued to receive honours. Between 1978 and 1984, these included ones from the Royal Society of Canada, the Canadian Standards Association, the Canadian Society for Civil Engineering, the Royal Society of Edinburgh, the (UK) Institution of Civil Engineers and the International Committee on Large Dams. The award from the Canadian Standards Association was its inaugural award.[20]

Personally, the end of this 1977-1984 period was a difficult time for Legget. In October 1984, his Ottawa family home on Echo Drive was broken into and a number of precious items were stolen. These included most of the medals he had been awarded and a watch fob that was a family heirloom.[21] Since that was all that was stolen, it appears that the thief knew what he or she was looking for.

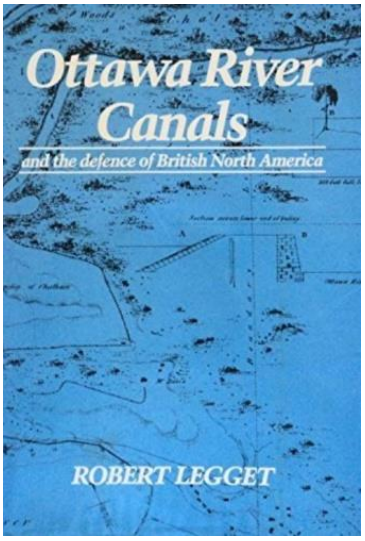
Just before Christmas 1984, Mary, Legget's wife of 53 years, died suddenly of a stroke. She had been ill in 1982 and was hospitalized but had recovered well enough by 1983 to convalesce at home and later that year travel again with Legget. Legget referred to Mary's 1982 illness and her 1983 recovery as a "misadventure." Mary Legget was cremated and her ashes were scattered; she has no gravesite or headstone.

1985-1992

In the mid-1970s, Legget wrote a short article for McGraw-Hill's *Encyclopedia of Engineering*. The topic was masonry construction. Legget started off the mid-1980s by writing 13 short articles on various topics for the *Canadian Encyclopedia*. Seven topics were related to Canadian engineers of the 1800s and early 1900s and six topics were related to construction.[22] Legget had researched and written previously about most of these topics in his various books and in his *Canadian Consulting Engineer* "Historical Notes."

In the mid-1980s, he also contributed four short biographies to the *Dictionary of Canadian Biography*—biographies of men who had in various ways contributed to the development of Canada in the first half of the 1800s.[23]

In 1986, the 2nd edition of Legget's *Rideau Waterway* was published (first published in 1955 and revised in 1972). The following year, a second edition of *Railways in Canada* was published (first published in 1973). In 1988, Legget published a new book, the 308-page *Ottawa River Canals and the Defense of British North America*, published by the University of Toronto Press.



Legget's *Ottawa River Canals* 1988

As mentioned previously, soon after the publication of *Handbook of Geology in Civil Engineering* in 1983, Legget started planning a 3rd edition of *Geology and Engineering*. He referred to the 3rd edition as "an abridged, student version of the [*Handbook of Geology in Civil Engineering]*." Once again, he invited Paul Karrow to be co-author; however, Karrow declined because of other work commitments and for personal reasons. Legget then invited Allen Hathaway and he agreed. Hathaway was an American consulting geological engineer who would later become a Professor of Geological Engineering at the University of Missouri—Rolla. Hathaway was primarily responsible for reducing the handbook in content and reducing the number of illustrations. Legget was responsible for reviewing and editing. Legget felt he couldn't do Hathaway's job because it would be like "murdering my own child." The 613-page result was published in 1988 by McGraw-Hill.

By the time the 3rd edition was published, the 1983 "Handbook" was out of print and

McGraw-Hill decided not to reprint it. Legget was not pleased. Over the 50 years that Legget had worked with McGraw-Hill, its upper management in New York had changed several times and the current management did not have the same loyalty to Legget. At the same time, the focus of McGraw-Hill was changing.

This change was evident in the fact that after its publication in 1988, the 3rd edition of *Geology and Engineering* was not well promoted by McGraw-Hill and sales were low. This greatly displeased Legget and, in a letter to the New York-based publisher, he wrote: [24]

> But the worst feature of all was that my [earlier] letters were either not answered at all, or answered in a vacuous way by writers who clearly knew nothing about the book or subject, writing from an address unknown to me…

In this time period, Legget's writing output decreased relative to previous periods. He only wrote a few papers in the geotechnical field, a few others associated with the history of engineering and geology, and one associated with engineering and society.

Two of his peer-reviewed geotechnical papers were published in the *Canadian Geotechnical Journal*: one in 1988 on "Thomas Roy and his 'Remarks on Road Making (1841)'." The other, published in 1993, was on "Donald MacDonald and the Panama Canal." Donald MacDonald was an early 1900s engineer from Nova Scotia.

In 1990, Legget published a short article in *The Beaver* magazine about his former NRC colleague and boss, C.J. Mackenzie. Sometime during this period, he also wrote a manuscript for a biography on C.J. Mackenzie and submitted it to the University of Toronto Press. That publisher, with which he had had a long association, was not interested in his manuscript; it was another blow to Legget.

On a brighter note, during this period Legget had 20 more "Historical Notes" published in the *Canadian Consulting Engineer*. In 1990, he was approached by Douglas and McIntyre Publishers (Vancouver, BC) to consider writing his autobiography. It's not known if Legget, now at the age of 86, considered the invitation, but nothing transpired.

Legget continued his practice of giving lectures. For instance, in 1986 alone, his 82nd year, he gave four major presentations:

- "Historical Perspectives for a Computer World," presented at the University of Waterloo.
- "The Engineering of Canada's Railways," to the Canadian Railroad Historical Association at McGill University.
- "The Value of Geology in Planning," presented to the Geological Society of London.
- "C.J. Mackenzie and Carleton University," the inaugural C.J. Mackenzie Memorial Lecture presented at Carleton University.[25]

This last lecture may have been Legget's impetus to write his biography of C.J. Mackenzie.

Legget gave only a few lectures after 1986. Almost all his lectures during his career, including those in his retirement, were given without any form of visual aid. He knew he could hold his audience's attention simply by crafting a good lecture and by delivering it in his engaging fashion.[26] Like Winston Churchill, Legget spent a lot of time preparing his lectures and

had a gift for public speaking that went back to his teenage years as a student at Merchant Taylors’ School.

In this late period of his life, Legget had one more organization to join and he was instrumental in its founding. In 1987, he became the founding President of the Canadian Academy of Engineering. This organization was established to honour distinguished Canadian professional engineers and to celebrate the 100 years since the formal beginning of engineering in Canada.[27]

Between 1985 and 1993, Legget continued to be honoured by various organizations including the ASCE and the (US) National Academy of Engineering.[28]

In 1989, he was awarded the Royal Bank Award and was promoted from an Officer to a Companion of the Order of Canada.

The Royal Bank Award was established in 1967, Canada’s centennial year, to honour Canadians "whose outstanding accomplishments make an important contribution to human welfare and the common good."[29]

A Companion of the Order of Canada recognizes “a lifetime of outstanding achievement and merit of the highest degree, especially in service to Canada or to humanity at large.” It is the highest non-military honour awarded in Canada. In 1989, along with Legget, seven other individuals received this honour from Governor General Jeanne Sauvé, the first female Governor General of Canada.

Companion of the Order of Canada Medal (photo source Governor General of Canada’s website)

Legget’s citation reads:[30]

> Founding President of the Canadian Academy of Engineering, he has firmly established his international reputation as a dedicated engineer, geologist, educator, historian and writer. Recent recipient of the prestigious Royal Bank Award, he has been honoured extensively by the most noted of learned societies and continues to be an important contributor to the global community.

The Royal Bank Award came with $100,000. Legget was embarrassed to receive the monetary portion of the award and told his son David that he would give all of it to charity. David

convinced him to hold back $10,000 for himself and use it to go on the trip he had always wanted to take—a cruise through the Panama Canal. Legget gave his remaining $90,000 to approximately 30 organizations.[31]

Legget took his son’s advice and took the Panama Canal trip in 1990. Canals had figured prominently throughout his life. His 1993 *Canadian Geotechnical Journal* paper, mentioned earlier, “Donald MacDonald and the Panama Canal,” resulted from this trip.

Left: Legget’s 1990 Panama Canal cruise ship the *Crown Odyssey*. Right: Legget during a life-saving drill on board the *Crown Odyssey*. One of the last photos taken of Legget. (both LAC Spec Coll)

Legget’s personal life during this 1985-1992 period was also busy. In 1985, he travelled to British Columbia to help celebrate the 100th anniversary of the completion of the Canadian Pacific Railway at Craigallachie, in BC’s interior. This trip would have satisfied his interests in railway and engineering history and his admiration for Sandford Fleming, the engineer in charge of the construction of the railway. In 1989, he helped plan celebrations for the 200th anniversary of the Scottish-Canadian explorer Alexander Mackenzie reaching the mouth of what is now known as the Mackenzie River.[32]

Legget and David Butcher, of the Calgary Tourism Association, at the 100th anniversary of the completion of the Canadian Pacific Railway in 1985 (LAC Spec Coll)

With the passing of Mary in 1984, Legget became more involved with the Anglican Church in Ottawa. He became the "Bishop's Man," an assistant to the Bishop in the Diocese of Ottawa. During this period, he gave a few lectures on religious topics.[33]

As was his habit dating back to the 1940s, Legget also visited Grand Manan Island several times. He became so well known to the local islanders that, in 1991, he was asked to write an introduction to the book *Wings Over the Sea*. In the book, author L.K. Ingersoll tells the story of the legendary Allan Moses, a fisherman and ornithologist from the island.

Legget on Grand Manan Island sometime in the 1980s, one of the very few photos of Legget not wearing a jacket, white shirt and tie (Photo source David Legget)

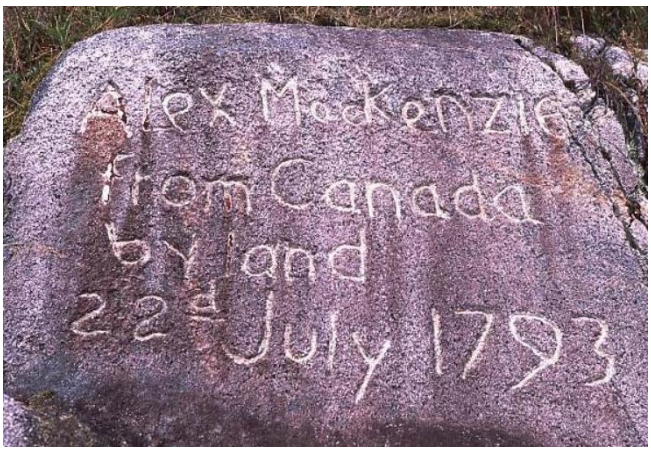
Throughout this period, Legget continued his life-long practice of answering all his mail, although after 1987 he seemed to have some trouble keeping up, a situation that bothered him. His handwriting deteriorated and even his typing skills were faltering.

Final years, 1993 and 1994

During this short period, Legget, who turned 89 in September 1993, continued to work.

On Canada Day, July 1, 1993, Legget wrote an unpublished review of the book *125 Years of Halcrow,* the corporate history published by the company that was once C.S. Meik and Buchanan, with whom he had worked in the 1920s. He took exception to some of the facts and the presentation and did not hold back![34] It is not known whether Legget sent this quite negative, review to the Halcrow Group.

Later that month, Legget headed off to Avoch, Scotland, about 250 km north of Edinburgh, where on July 22, 1993, with a small group of Sir Alexander Mackenzie admirers, he laid a commemorative plaque on the explorer's burial site. The plaque, arranged by Legget, celebrated Mackenzie's arrival at the Pacific Ocean near Bella Coola, exactly 200 years prior to the day.[35]



Left: Sir Alexander Mackenzie's burial site with the commemorative plaque in the centre between the two headstones; the right headstone is that of Mackenzie[36] and his wife; the left headstone is that of two of his sons. (photo source findagrave.com). Right: The commemorative plaque is a replica of the stone that Mackenzie engraved near Bella Coola, BC

Later that summer, Legget contributed to, "starred" in and narrated some of the 24-minute documentary on "John By, Hero without Honour, the Rideau Canal Story." The documentary was completed after Legget's death and was dedicated to his memory.[37]

In September 1993, Legget travelled to Saskatoon and attended the 46th Canadian Geotechnical Conference, the conference he first organized in Ottawa in 1947. As was his custom, whenever he could since 1970, he personally presented the Robert F. Legget Award, the Canadian Geotechnical Society's most prestigious award. The recipient of the award in 1993 was Raymond Yong, a professor at McGill University.

In October 1993, Legget travelled again to the UK, this time to attend the 175th anniversary dinner of Honorary Fellows of the Institution of Civil Engineers. He flew from Ottawa to Boston, and because of flight delays, via New York where he had to overnight, then to London—a trip of approximately 24 hours. On his return, he stopped in Boston to attend the annual meeting of the Geological Society of America.

In December 1993, Legget wrote to McGraw-Hill in New York and pitched a 4th edition of *Geology and Engineering*, again with Hathaway as co-author. Nothing further came of this.

That same month, he sent out his typical Christmas card consisting of an historical photo with a hand-calligraphed caption and a salutation handwritten in Old English. It was to be his last.

In March 1994, he wrote an unpublished piece he entitled "The Good Samaritan." It was about a Samaritan that he had encountered during his long and convoluted from Ottawa to London the previous October.[38]

Sometime in this short period, Legget found time to write three more "Historical Notes" for the *Canadian Consulting Engineer*. The last note was published posthumously, a month after his death.

On Sunday, April 17, 1994, Legget's sister Lucy, then 86 years old and living in England, telephoned Legget's Ottawa home. It was customary that they talk on Sunday every couple of weeks. When Legget did not answer the phone, Lucy contacted one of his neighbours. The neighbour found Legget unconscious in his house at 531 Echo Drive. He died later that day in

Ottawa’s Riverview Hospital, having suffered a stroke.

A service for Legget was held the following week at the historic stone Christ Church Cathedral, the Anglican cathedral for the Diocese of Ottawa where Legget had volunteered as the Bishop’s assistant for the last few years of his life. Being the practical man he was, Legget had everything for his funeral planned and had even written some of his own obituary. Like his wife Mary, Legget was cremated and his ashes scattered. Like Mary, he has no gravesite or headstone.

Unlike the situation for many individuals who die at the age of 89, anyone who knew Legget could not say, on hearing of his passing, “I didn’t know he was still alive.” He was active and engaged right up to the end of his life. The week before he died, he had given a lecture in Ottawa.

News of Legget’s death travelled quickly throughout Canada, the United States and beyond. Obituaries were published immediately after his death in the *Ottawa Citizen, The Globe and Mail* and the *Independent* (the latter two written by former DBR colleague Lorne Gold). In the following weeks and months, obituaries were also published by the Canadian Geotechnical Society (written by former DBR colleague Carl Crawford), the *Canadian Consulting Engineer* and the DBR *Structures News* (both written by Lorne Gold), the Geological Society of America and *Environmental & Engineering Geoscience* (both written by former co-author Allen Hathaway), the (US) National Academy of Sciences and (US) National Academy of Engineering (both written by Alan Davenport, a professor at the University of Western Ontario, London, ON and a specialist in analyzing wind effects on buildings), and the Royal Society of Edinburgh (by Hugh Sutherland, a long-time University of Glasgow professor and sometimes DBR, colleague).[39]

Annotations Chapter 20: "RETIREMENT" YEARS (1970-1994)

[1] For both the 1st (1939) and 2nd (1962) editions of *Geology and Engineering* and for *Cities and Geology* (1973), Legget did his own subject indexing at the back of his books. Today, subject indexing has become somewhat of a science and is typically done by professional subject indexers.

[2] Legget's geotechnical contributions are listed in Chapter 23.

[3] The titles of almost all of Legget's 108 "Historical Notes" and his six "Historical Geological Notes" are listed in Chapter 23.

[4] LAC 3-6

[5] The awards and honours that Legget received between 1970 and 1976 were as follows:

- 1970: Engineering Institute of Canada's inaugural Julian C. Smith Medal for "achievement in the development of Canada."
- 1970: American Society for Testing Materials Walter C. Voss Award for "outstanding contributions in the fields of geology, engineering and building materials" and for "dedicated service in advancing the cause of standardization."
- 1970: Association of Professional Engineers of Ontario's (now Professional Engineers Ontario) inaugural Gold Medal.
- 1971: Canadian Fire Safety Association Life Member.
- 1971: Association of Engineering Geologists Honorary Member.
- 1972: Canadian Council of Professional Engineers (now Engineers Canada) inaugural Gold Medal.
- 1972: Geological Association of Canada Logan Gold Medal.
- 1974: Association of Engineering Geologists Claire P. Holdridge Award.
- 1974: Standards Engineering Society Leo B. Moore Medal for being "one of the most persistent and vigorous contributors to the field of standards, both nationally and internationally."
- 1976: Geological Society of Belgium Dumont Gold Medal.

[6] Between 1970 and 1976, Legget received the following honorary degrees:

- 1971: Doctor of Laws (LLD) from University of Glasgow
- 1971: Doctor of Engineering (DEng) from University of Liverpool
- 1972: Doctor of Science (DSc) from Thomas S. Clarkson College of Technology (now Clarkson University), Potsdam, NY
- 1972: DSc from Sir George William University (now part of Concordia University), Montreal
- 1972: DEng from the Technical University of Nova Scotia (now part of Dalhousie University), Halifax, NS, and
- 1974: DEng from Carleton University, Ottawa.

[7] The Canadian Geotechnical Society, formed in 1972, was the offspring of:

- the Associate Committee on Geotechnical Research (and its predecessor the Associate Committee on Soil and Snow Mechanics) that Legget chaired from 1945 to 1967 and
- the Geotechnical Engineering Division of the Engineering Institute of Canada which Legget helped co-found in the early 1960s.

[8] "Robert F. Legget award and medal" recipients are listed in the annotations in Chapter 17.

[9] Sandford Fleming is introduced in Chapter 7 and in its annotations.

[10] William Smith is introduced in Chapter 13 and mentioned in the annotations of Chapter 19.

[11] Paul Karrow (born 1930) obtained his bachelor's degree from Queen's University in Kingston (1954) and his PhD from University of Illinois—Urbana (1957). After working with the Ontario Geological Survey for several years, he helped established the Earth Sciences Department at the University of Waterloo in the early 1960s. Karrow also has an interest in archeology and was President of the Ontario Archeological Society in 1963 (Canadian Quaternary Association website).

[12] For comparison, the 2nd edition of *Geology and Engineering* had 884 pages and 315 illustrations.

$94.50 in 1983 would be equivalent to approximately CAD$240 in 2020.

[13] *Musk-Ox* was a journal published by the University of Saskatchewan's Institute of Northern Studies.

[14] The topic of Legget's last news item for *EN-R* was the Government of Canada giving support to CP Rail for its 15-km tunnel beneath Rogers Pass in BC. Excavation for that tunnel, now known as the Mount MacDonald Tunnel, began in 1984 and the tunnel was completed and opened in 1988.

[15] In a 1983 Christmas letter, Legget mentioned the writing of his 1983 geotechnical memoir, "…it finished up as an essay of 35,000 words and almost all from memory which worked like a charm once I got started" (LAC 3-7).

[16] LAC 9-6

[17] LAC 9-8

[18] LAC 9-9

[19] LAC 9-4 and 9-5

[20] The awards and honours Legget received between 1977 and 1984 were:

- 1977: Honorary Member of the American Society of Civil Engineers
- 1977: Engineering Institute of Canada's most prestigious Sir John Kennedy Medal
- 1977: The inaugural William Smith Medal from the Geological Society of London
- 1978: Honorary Member of the International Committee on Large Dams
- 1979: The inaugural John Jenkins Award from the Canadian Standards Association
- 1980: Honorary Fellow of the (UK) Institution of Civil Engineers, which he joined as a Student Member in 1925 and became an Associate of in 1930
- 1983: Honorary Fellow of the Royal Society of Edinburgh
- 1983: Fellow of the Canadian Society for Civil Engineering, and
- 1983: Centenary Medal of the Royal Society of Canada.

[21]The items stolen were, as listed by Legget (LAC 1-11):

- Medaille d'Or of the Canadian Council of Professional Engineers, gold or gold alloy
- Dumont Gold Medal of the Geological Society on Belgium, solid gold
- Logan Gold Metal of the Geological Association of Canada, solid gold
- John Kennedy Medal of the Engineering Institute of Canada, dark alloy
- Julian C. Smith Medal of the Engineering Institute of Canada, dark alloy
- William Smith Medal of the Geological Society of London, silver
- Centenary Medal of the Royal Society of Canada, bronze
- Past President lapel pin from the ASTM, gold with a diamond
- Honorary Member lapel from the American Society of Civil Engineers, solid silver, and
- Watch fob, gold, for evening wear (a family treasure, over 50 years old).

(A watch fob is an ornamental chain that attaches a pocket watch to a pocket in a man's dress coat.)

In 2012, the Logan Gold Medal was found in La Vérendrye Park, approximately 10 km east of Ottawa.

[22] The *Canadian Encyclopedia* was an initiative of Random House Publishers and Mel Hurtig, an independent Canadian publisher. When first published in 1985, the three-volume set sold for $125 and sold out within days of publication (Wikipedia). Legget's contributions were put online in the late 2000s Canadian Encyclopedia-Legget and the short articles have since been revised.

The seven Canadian engineers of the 1800s and early 1900s were: Colonel John By, Simon James Dawson, Richard Hearn, Joseph Hobson, Sir John Kennedy and the Shanley brothers Walter and Francis. The six topics related to construction were: bridges, canals and inland waterways, history of the construction industry, tunnels, the Rideau Canal and the Trent-Severn Waterway.

[23] The *Dictionary of Canadian Biography* began in 1959 and is a collaboration between the University of Toronto and Université Laval. It is arranged chronologically by year of death or last known activity and

currently extends up to 1930 (Wikipedia). It is now available online.

The four biographies contributed by Legget were: Colonel John By, Henry Abraham Duvernet, Thomas Roy and Nathanial Hazard Tredwell.

[24] LAC 10-9

[25] C.J. Mackenzie, Legget's former NRC colleague and boss, was Chancellor of Carleton University from 1954 to 1968.

[26] In 1983, Legget was scheduled to present a lecture to the Manitoba Section of the Canadian Geotechnical Society on the 1880s construction of the Canadian Pacific Railway. Ken Skaftfeld, a young engineering student at the time who knew little of Legget, helped organize the event. Ken recalls phoning Legget in Ottawa and asking him to confirm his audio-visual requirements. Legget politely replied that he didn't need anything at all and that if he couldn't present his lecture without slides, he wasn't much of a lecturer.

Ken was a little anxious as to how the lecture without slides ("just plain talking") would go over with the audience—that is, until Legget started to talk. Ken recalls that, "You could have heard a pin drop" the entire time Legget presented his lecture on "The Last Spike." It's something Ken has never forgotten. Nor has he forgotten the letter of thanks he received from Legget, addressed to "Mr. Ken Skaftfeld, Esquire."

[27]The formal founding of engineering in Canada is considered to be the formation of the Canadian Society of Civil Engineers in 1887. In 1918, it was renamed the Engineering Institute of Canada.

[28] Legget's honours between 1985 and 1994 included:

- 1986: ASCE's Can-Am Civil Engineering Amity Award "in recognition of his career achievements in research, education and as a consultant to the Canadian and United States governments …. for exemplary career activity which has added to the amity between Canada and the US."
- 1988: (US) National Academy of Engineering Foreign Associate, the designation given to non-US citizens. The academy was established in 1964 as part of the National Academy of Sciences. Election to the NAE is among the highest recognitions in engineering-related fields.
- 1989: Canadian Public Works Association Honorary Member (Legget was a member of its National Editorial Committee).
- 1989: Royal Bank Award.
- 1989: promotion to a Companion of the Order of Canada, and
- 1992: (US) Public Works Historical Society Honorary Member.

Sometime during this period, Legget also became an Honorary Member of the American Underground Construction Association and an Honorary Life Member of the Rideau Valley Conservation Authority.

[29] Other recipients of the Royal Bank Award included Cardinal Paul-Émile Léger, novelist and playwright Morley Callaghan, architect Arthur Erickson, literary writer Northrop Frye, writer Hugh MacLennan, athlete and philanthropist Rick Hansen, opera singer Maureen Forrester, geneticist and environmentalist David Suzuki, and the previously introduced C.J. Mackenzie.

In 2000, the Royal Bank redirected the award to honour innovative organizations and forward-thinking projects. The following year was the last year the award was presented.

[30] Governor General of Canada's website

[31] Of the $90,000, Legget gave approximately 30% to religious organizations, 20% to hospitals and care facilities, 20% to schools and universities, 20% to museums and historical organizations and 10% to professional and technical organizations (LAC 1-19 and 1-20).

[32] Several of Legget's obituaries refer to him writing a book on Sir Alexander Mackenzie, or on "Mackenzie's River," near the end of his life. If he did, it appears that the book was not published. His obituary writers may have confused Legget's manuscript on C.J. Mackenzie with a book on Alexander Mackenzie.

[33] David Legget, personal communication

[34] Legget did not agree with the date given in *125 Years of Halcrow* for changing the name of the firm from "C.S. Meik and Buchanan" to "C.E. Meik and Halcrow." He thought that the book stated it at least seven years early.

> More serious, however, is the fact that I just can not see for whom the publication is intended! I see that it was prepared by 'Halcrow Group Marketing' (whatever that is). If I were a prospective client, I would not be impressed by the illustrated reference to the failure of the first Tay Bridge, or to the quite tragic career of Sir George Buchanan. If I were a member of staff, past or present, I would expect to see an accurate record of accommodation, and of the chief executive officers. Neither is there.

Legget also regretted the book not having a photo of the firm's original office at 16 Victoria Street in London, a photo that Legget had provided in 1984. In addition, "Some of the illustrations are outstanding but the captions are not up to the same standard… And the use of a copy of a newspaper photo of a locomotive on p 7 is a sad blemish! Some of the 'arty' non-engineering illustrations are merely tedious" (LAC 19-12).

[35] Alexander Mackenzie was the first European to cross the continent of North America.

[36] Alexander Mackenzie's headstone reads, "In memory of Sir Alexander Mackenzie of Avoch. The explorer of the North West of America and discoverer of the Mackenzie River. Died 12 March 1820."

[37] LAC 20-7. The documentary, produced by Josephine MacFadden, is on the CGS website under Virtual Archives at CGS John By Documentary.

[38] It is worth reading Legget's story in his own words, written in March 1994, when he was 89 years old, a month before his death (LAC 9-16).

A GOOD SAMARITAN…1993

> Travel by way of Boston was desirable for my second visit of 1993 to the United Kingdom in October 1993 (to attend the 175th anniversary dinner of Honorary Fellows at the Institution of Civil Engineers, which I joined as a student in 1925!) since I had to come back to attend the annual meeting of the Geological Society of America, in Boston. Accordingly, I flew by Delta Airlines from Ottawa to Boston. Boston Airport had been fogged in and closed for most of the day and so we were much delayed, my plane reaching Boston after my connecting plane to London had departed at 7:00 pm. (We arrived at 7:40 pm.)
>
> Despite the extreme inconvenience of the enlarged Logan Airport at Boston, I finally managed to get to the American Airlines counter at 8:40 pm where I received quite wonderful service, despite the chaotic day that the attendants were then just finishing. Although she must have been tired out, the young lady who served me could not have been more helpful. She first contacted British Airways and found that they had a seat available on their 9:00 pm flight to London. Then she looked at her watch and told me that I could not reach the British Airways counter in one of the other buildings in time to catch the flight! "But I've kept the worst news to the last—there isn't a single hotel room available in Boston tonight." "What shall I do? Spend the night in the Airport?"… "I wouldn't; I'd go to New York."
>
> New York! And in no more than five minutes she had it all arranged—a seat on the last flight out of Boston that night; a room booked at the Midway Motel near Kennedy Airport; and a seat on the American morning flight to London. Her final instructions were, "Now at Kennedy go to the lower level and you will find a shuttle bus and driver waiting for you from the Motel". Most fortunately I had my bag so I was soon in the air en route to New York. Arriving there about 10:30, I followed instructions and went to the lower level but no driver or shuttle bus! "Oh! yes, he was here earlier in the evening but he left long ago." I walked outside and stood on the curb wondering what to do—no room, no US funds! As I stood there metaphorically "scratching my head," a small man got out of a vast car waiting there, Chinese in appearance in a leather cap and windbreaker. He walked over and asked, "Are you in trouble, Sir?"
>
> "Well, not trouble exactly"… "but you look worried"… "I am." When I told him why he wanted to

know who booked me at the Midway. “They must be crazy; it’s ten miles or more away. We have lots of places round the Airport; I have a little list.” …and he took out a small notebook with a dozen motels listed with telephone numbers. “Now shall I try the first? It’s Chinese, but very clean, nice people and only $65 a night.” When I told him I had no US money *[to make the phone call]*, he said not to worry, he had and would call, which he did. They were full up. “Let’s try the second one, Travelodge.” Back he went to the telephones, coming back to say that they did have a room…” but it’s terribly expensive, $125 a night!” I told him that the airline would be paying for it so let’s book it, which he did, with yet another call. [He came] back to say that all was well; they would radio to their shuttle bus driver who was at the Airport, telling him to wait until I got there “… and I know exactly where he stands so I can show you where he is” which he then proceeded to do. I tried to express my gratitude for this wonderful help, explaining that I had no US funds but asking him if he would accept a Canadian $2 bill to pay at least for the telephone calls. “Certainly not, Sir” was his reply with a broad smile, “if we can’t help a visitor to New York when he’s in trouble, there is something wrong with the world.”

I then said “Well at least tell me your name”… “Wilson”… “And where do you work?” He pulled his windbreaker open, revealing a sweatshirt with the AIRPORT HILTON printed across it. “But, why didn’t you send me there?”… “Oh!, they are far too expensive!”

…all this in New York, in 1993.

The driver of the shuttle bus was equally kind, a rotund, jolly Anglo-Saxon, lifting my bag on to and off the bus, assuring me that my room would be all right and was being held (as it was) and saying that he’d see me in the morning since this was his swing shift, this he did, still jovial, again most helpful, refusing very graciously any tip (I had changed some Canadian money). “Not at all, Sir, it has been a privilege to serve you.” Wonderful day-flight, getting to Heathrow as it was closing for the night but got the last bus to Marble Arch and to my hotel by 11:30 pm that Sunday evening.

[39] These obituaries were in files obtained from Michael Bozozuk and Elizabeth White, in addition to those that are online.

Chapter 21: THE LEGGET LEGACY

Looking back over the more than 25 years since 1994, the year Robert Legget died, we can remember him for his many contributions. Reviewing his life, we can see how the path Legget followed led to his legacy.

After gaining experience working on engineering projects in the UK and in northern Ontario, Canada, in the late 1920s and early 1930s, Legget introduced the Larssen Sheet Piling system to eastern Canada. From the experience he gained from these early jobs, along with the appreciation of geology that he obtained as a student at the University of Liverpool, Legget recognized the value of geology in civil engineering, specifically geotechnical engineering. His attendance at the first International Conference on Soil Mechanics and Foundation Engineering in 1936 expanded his appreciation of the value of geology in civil engineering and introduced him to many early soil mechanics practitioners from around the world. He parlayed all these experiences into what became his first textbook, *Geology and Engineering*, published in 1939.

While at Queen's University between 1936 and 1938, Legget started the first rudimentary soil mechanics laboratory in eastern Canada.[1] Moving to the University of Toronto in 1938, he established a more sophisticated soils laboratory. In 1940, he accepted the first graduate student in the geotechnical field in Canada. During his nine years at U of T, Legget promoted and taught soil mechanics in the undergraduate civil engineering curriculum as well as to practicing civil engineers.

By bringing his practical experience to academia, Legget planted seeds of knowledge that continued to bear fruit long after he moved on. At U of T, Legget taught scores of students, several who went on to have illustrious careers in the geotechnical field.[2]

During his time at U of T, Legget also contributed to several significant war-time and early post-war projects, including the Shipshaw Hydroelectric Power project and the beginning of the Toronto subway system. In most of these projects, he stressed the importance of geology. Legget also became quite involved with Ontario's environmental conservation movement that led to the 1946 *Conservation Authorities Act of Ontario.*

In 1945, Legget was asked to chair a new committee of the National Research Council (NRC)—the Associate Committee on Soil and Snow Mechanics. Among other accomplishments in this capacity, he helped establish a national research program in the geotechnically-related fields of soil mechanics, permafrost and muskeg, and he organized the first Canadian geotechnical conference.

Two years later, Legget accepted the challenge of becoming the founding Director

of the NRC's Division of Building Research (DBR). As director, he developed a first-rate federal research institute, both in the geotechnical field and in building research—construction, standards, codes and fire protection—and hired many excellent researchers. He introduced the field of soil mechanics io the National Building Code of Canada. Due to these other commitments, Legget's own geotechnical research tapered after 1947.

Following the success of the first Canadian soil mechanics conference in 1947, Legget and the DBR were instrumental in organizing, and publishing the proceedings of, the next 15 annual Canadian soil mechanics conferences. These conferences, now known as Canadian Geotechnical Conferences (and now organized by the Canadian Geotechnical Society), have resulted in the longest running series of annual national geotechnical conferences in the world. They have been instrumental in transferring geotechnical knowledge among practitioners and to younger colleagues.[3]

In the late 1950s and early 1960s, Legget worked behind-the-scenes to help establish a more formal federal earth science research grants program that included geotechnique in its broadest form.[4] He helped establish the *Canadian Geotechnical Journal* that published its first issue in 1963. He also helped establish the Engineering Institute of Canada's Geotechnical Engineering Division that, in 1972, evolved into the Canadian Geotechnical Society (CGS).[5]

In the early 1960s, Legget chaired the organizing committee for the 6th International Conference on Soil Mechanics and Foundation Engineering that brought 1,300 Canadian and international delegates to Montreal in 1965. He did this while serving a four-year term as Vice President North America of the International Association for Soil Mechanics and Foundation Engineering. After the conference, Legget ensured that some of the proceeds from that successful conference was used to establish the very successful, and still running, Cross Canada Lecture Tour series, and to establish the Canadian Geotechnical Fund (now known as the Canadian Foundation for Geotechnique).[6]

Legget remained Chair of the NRC's Associated Committee on Soil and Snow Mechanics until 1967 but, before handing over the reins to his successor, he modernized its name to the Associated Committee on Geotechnical Research.[7]

For all the above achievements, he is considered one the "Fathers of Canadian Geotechnique"[8] and the driving force behind the organization of the geotechnical profession in Canada.

Throughout his life, Legget was a member of many organizations, both in Canada and abroad. A few organizations, such as the Canadian Academy of Engineering, he helped establish. Typically, he served in some capacity on the executive committees of most of these organizations. He served as president the Geological Society of America

for one year, the American Society of Testing Material for two years and le Conseil International du bâtiment pour la recherche l'étude et la documentation (CIB) for four years.

Legget used his many publications and lectures to help promote geotechnique and move the profession forward. An analysis of his publications[9] indicates that approximately half of the books that he wrote relate to geotechnique and geology. Of his more than 500 other publications, approximately 25% relate to geotechnique and geology, as did approximately half of his many lectures.

While Director of the DBR, Legget also contributed greatly to the development of Canadian building research. The geotechnical community in Canada may not be aware of this aspect of Legget's career. Approximately 15% of his publications relate to building construction, standards, codes and fire protection. Legget considered his contributions to the National Building Code of Canada and the associated National Fire Code of Canada to be two of his more significant achievements during his 22 years as Director of the DBR. Legget's writing, lectures, involvement with organizations and extensive travel helped promote Canadian building research across the country and around the world.

Legget's passions extended to the history of early engineers and geologists in Canada and their achievements. Approximately half of the books he wrote relate to early Canadian engineering achievements, primarily canals and railways. Of his many other publications, approximately 25% relate to the history of Canadian engineering and geology, the same percentage as his geotechnical and geological-related publications. Legget often wove history into his technical publications and lectures, and vice versa.

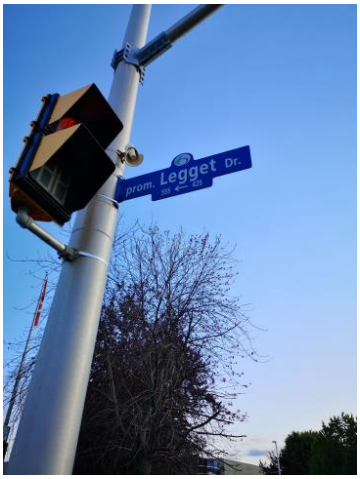
Legget helped promote the 100th anniversary of the completion of the Canadian Pacific Railway (1885) and the 200th anniversaries of Sir Alexander Mackenzie's epic journeys of exploration to the mouth of the Mackenzie River (1789) and to the Pacific Ocean (1793). In the last years of his life, Legget was successful in finding the elusive birthplace of Colonel John By, the man behind the engineering and construction of the Rideau Canal.[10]

When measuring Legget's accomplishments, it should be remembered that up until the mid-1950s most long-distance travel in North America was by train and most international travel was by steamship. He started to fly regularly only after the mid-1950s. During the early part of his career, long-distance communication was difficult, slow or expensive, by current standards, and achieved primarily by mail, telegram (and later telex) and long-distance telephone—only reliable in North America starting in the late 1950s and internationally in the 1970s.

Where do you see the name Robert F. Legget, Robert Legget or Legget today? On the covers of his books, in the bylines of his other publications, on lists of recipients of

many awards and honours and in reference lists in publications by others. But he is remembered elsewhere as well.

The Ottawa area features several “Leggets.” Legget Drive, located in the Kanata area west of downtown Ottawa, is in a light industrial-tech park area that has several streets named for prominent Canadians.[11]



Legget Drive in Kanata, ON (photo by Véronique Boucher 2019)

Legget Avenue is in NRC’s Montreal Road Campus, on the north side of Montreal Road. It runs past the Building Research Centre that Legget was instrumental in having designed and constructed in the early 1950s. In 1996, shortly after his death, the NRC renamed the Building Research Centre the R.F. Legget Building in honour of the founding Director of the Division of Building Research.[12]

Left: Legget Avenue with R.F. Legget Building at the top of the photo (photo source Google Maps 2020). Above: Main entrance (photo by Harry Baker 2019)

Robert F. Legget Park, dedicated in 1996, is located at the corner of Main and Clegg streets in Ottawa, a short walk from where Legget lived on Echo Drive. According to the City of Ottawa Archives dedication papers, “Canadians have to thank Robert Legget for wheelchair ramps, smoke detectors and hard hats for construction sites.” It is now a children’s garden park.

Robert F. Legget (Children's Garden) Park, Ottawa (photos by Doug VanDine 2019)

The Legget Memorial Monument is appropriately located near the entrance locks to the Rideau Canal at the confluence with the Ottawa River, just below Parliament Hill **(**N 45°25.541; W 075°41.840). Its construction and erection were initiatives of the CGS's Ottawa Geotechnical Group, headed by former Legget student Gordon McRostie. The monument was unveiled during a 1997 ceremony of the 50th Canadian Geotechnical Conference. Two benches near the monument site were added with funding from the CGS.

The monument is a concrete structure and includes special pieces of rock contributed by about 200 of Legget's friends from Canada, the US, Scotland, England, Switzerland, Italy and Australia.[13] The inscription in both English and French reads:

> In memory of an outstanding engineer and geologist. Pre-eminent historian of the Rideau Waterway, of Canada's rivers, railways and canals; ardent advocate of the preservation of this nation's beauty and ecology.

Legget Memorial Monument, Ottawa (photo by Heinrich Heinz, 2012)

The Ottawa-based Rideau Valley Conservation Foundation has the Legget Endowment Fund. It was established in 1989 with funding by Legget from a portion of the money from his 1989 Royal Bank Canada Award. The fund is used for conservation efforts in the Rideau Valley.

Outside the Ottawa area, Legget used a portion of his 1989 Royal Bank Canada Award to establish the Robert Legget Prize at his former *alma mater*, the University of Liverpool. The prize is given annually "to a student of the Faculty [of Engineering] submitting an especially distinguished thesis for the award of a PhD degree." On the University of Liverpool's website, Legget is recognized as one of its "Notable Alumni", and is described as a "civil engineer, historian and non-fiction writer."

In 1993, the (US) Association of Engineering Geology[14] established the Robert F. Legget Publication Fund to "support publication and public outreach in environmental and engineering geology." It is not known whether Legget helped establish this fund, or whether others donated to this fund in his honour.

The 1994, 24-minute documentary on "John By, Hero without Honour, the Rideau Canal Story," to which Legget contributed and helped narrate in the year before he died, is dedicated to his memory.

In 1998, the Geological Association of Canada published Special Paper 42, *Urban Geology of Canadian Cities.* This 25-chapter volume, edited by Paul Karrow and Owen White, summarizes the geology beneath major Canadian cities and is dedicated to Legget.

As mentioned in Chapter 17, the annual Robert F. Legget Award, the first geotechnical award in Canada, was inaugurally presented in 1970. It is now awarded at the annual Canadian Geotechnical Conference by the Canadian Geotechnical Society and is the society's most prestigious honour. In 2000, the award was changed to a medal, funded by the Canadian Foundation for Geotechnique.[15] The medal was designed by Michael Bozozuk, Legget's colleague in the DBR and the President of the Canadian Foundation for Geotechnique from 1999 to 2004. Its shape is 13-sided to represent the provinces and territories of Canada. The many sides of the medal can also be said to represent the many sides of Legget.

The two sides of the CGS's Robert F. Legget Medal
(photo source Canadian Foundation for Geotechnique)

Keeping with the times, Legget's name and a brief synopsis of his life appears on Wikipedia. When the *Canadian Dictionary of Biographies* catches up to the latter half of the 20th century, Robert Legget will undoubtedly have a place there as well.

Annotations Chapter 21: THE LEGGET LEGACY

[1] Ibrahim Morrison established a rudimentary soils laboratory at the University of Alberta in 1930 (Morrison 1997).

[2] Following are some of Legget's U of T students who went on to have illustrious careers in the geotechnical field.

- Per Hall, Legget's graduate student, went on to become President of FENCO, a subsidiary of the Foundation Engineering Company of Canada, before forming his own consulting firm specializing in underwater tunnels.
- Lionel Peckover: U of T 1944, worked with Legget at DBR and went on to become Chief Soils Engineers with the St Lawrence Seaway Authority, then Engineer of Geotechnical Services for CN and is considered the "Father of Canadian Railway Geotechnique."
- Gordon McRostie: U of T 1944, in 1950 formed the first independent geotechnical consulting company in eastern Canada and continued practicing in the field until he died in 2018.
- Don MacDonald: U of T 1945, worked with Legget on the early Toronto subway system and eventually became President of H.G. Acres and Company.
- Bill Eden: U of T 1949, worked closely with Legget at the DBR and on the Associate Committee on Soil and Snow Mechanics and Associate Committee on Geotechnical Research, and
- Don Bazett: U of T 1949, had a stellar geotechnical career, both with Ontario Hydro and in geotechnical consulting in British Columbia. He served as Editor of the *Canadian Geotechnical Journal* from 1975 to 1980.

Short memoirs of the latter five individuals are on the CGS website (see Chapter 24).

[3] The 73rd Canadian Geotechnical Conference is being held in September 2020 as a virtual conference because of the COVID-19 pandemic.

[4] This research grants program is now known as the Natural Sciences and Engineering Research Council of Canada's (NSERC's) Earth Sciences Research Grants.

[5] In the early 1980s, when the CGS Engineering Geology Division decided to present an annual award for an outstanding contribution to engineering geology, Legget suggested that the award be named after Thomas Roy, an early 1800s British-born geologist who spent much of his career working in Canada and may have been North America's first engineering geologist.

[6] See CGS News in *Geotechnical News* (September 2017) for more on the history of the Cross Canada Lecture Tour. A list of all past Cross Canada Lectures from 1965 to the present are listed on the CGS website. The history of the Canadian Foundation for Geotechnique is on the CGS website under Virtual Archives.

[7] The Associate Committee of Geotechnical Research was disbanded in 1990 and evolved into the CGS's Geotechnical Research Board.

[8] Robert Hardy from the University of Alberta is considered the other "Father", while Ibrahim Morrison, an earlier colleague of Robert Hardy at the U of A, is considered the "Grandfather of Canadian Geotechnique".

[9] See Chapter 23

[10] Eventually Legget found John By's birthplace—across the Thames River from the British Houses of Parliament—and started to arrange for a plaque. Shortly after Legget's death, a plaque was erected at John By's birthplace, paid for by Legget's son, David.

[11] The other streets in the areas are named for: Clarence Farrar, an influential psychiatrist and first Director of the Toronto Psychiatric Hospital/Clark Institute; Omond Solandt, a medical doctor who became the first Chairman of the Canadian Defense Research Board; William Schneider, a chemist who became President of the National Research Council (1967-1980); Gerhard Herzberg, a German-Canadian physical chemist who won the Nobel Prize for Chemistry (1971) and Terry Fox, a Canadian athlete and cancer research activist. Solandt, Schneider and Herzberg were NRC colleagues of Legget.

[12] In the foyer of the R.F. Legget Building there is a display case dedicated to Legget. It contains several pieces of memorabilia including his slide rule, his 1939 textbook *Geology and Engineering*, his (UK) Institution of Civil Engineers member certificate (1944); his Architectural Institute of Canada honorary fellow certificate (1953), his honorary DEng certificate from the University of Liverpool (1971) and his Companion of Canada certificate and medal (1989).

The R.F. Legget Building currently houses the Federal Research Centre for Applied Chemistry. In 2009, the building became a "Recognized Federal Heritage Building." See Canada's Historic Places NRC M-20.

[13] See CGS Heritage Committee. 2020. "Legget Memorial Monument," *Canadian Geotechnique/ Géotechnique canadienne*, Vol 1, No 2, pp 30.

[14] In 2004, the association was renamed the Association of Environmental and Engineering Geology.

[15] The Robert F. Legget award and medal recipients, up to 2019, are listed in the annotations to Chapter 17.

Chapter 22: LEGGET: HIS MENTORS; A MENTOR

Robert Legget's life (1904-1994) spanned most of the 20th Century. He lived during the reigns of four kings and one queen of England. He lived through two world wars and one major depression. He witnessed the rise in the popularity of the automobile and the development of air and space travel. Although he never made use of them, in his later life he was well aware of hand-held calculators and personal computers.

Legget grew up in a middle-class family in Liverpool, England. He was a bright student and was fortunate enough to obtain a scholarship to attend the University of Liverpool and to be guided into civil engineering. There, he was introduced to his first mentor, P.G.H. Boswell, his geology professor. In 1993, in Legget's last published paper, he refers to Boswell as "my revered instructor in geology at the University of Liverpool, P.G.H Boswell…" (*Canadian Geotechnical Journal*, p 555).

For a few years after university, Legget worked primarily on hydroelectric power projects under the positive tutelage of (later Sir) William Halcrow, an experience he treasured.

Immigrating to Canada in late 1929, Legget initially worked in dam construction but then during the Depression had to change his focus and he worked on projects associated with steel pile design and installation. During this period, he recognized and started publishing articles about the importance of geology and civil engineering. In 1936, he attended the first International Conference on Soil Mechanics and Foundation Engineering at Harvard University. There he met another future mentor, Karl Terzaghi, and other influential pioneers in the emerging field of soil mechanics. From this conference, Legget's passion and enthusiasm for the subject blossomed.

Legget spent a little more than a decade in academia, briefly at Queen's University and then at the University of Toronto. At the former he worked closely with Sandy Macphail; at the latter, closely with C.R. Young. He developed a tremendous amount of respect for these two mentors. Legget introduced soil mechanics to these institutions and became a mentor himself, to several of his U of T students.

Near the end of the Second World War, through his hard work, his publication record and the personal contacts he had made, Legget was asked to be the Chair the National Research Council's Associate Committee on Soil and Snow Mechanics. Two years later he was hired as the founding Director of the NRC's Division of Building Research in Ottawa. For the first few years in Ottawa, Legget worked closely with another engineer for whom he developed great respect, C.J. Mackenzie, an individual who became another mentor.

In the 22 years that Legget was Director of the DBR and again due to his hard work and his character, ethics and interpersonal skills, he developed a first-rate federal research institute. During these years he worked tirelessly as an effective leader to promote building research in its broadest sense, including the development and organization of geotechnique in Canada. Legget became a mentor to many younger professionals, both inside and outside his organization.

In retirement, and up to the end of his life, Legget continued to pursue his passions, both

technical and historical, with great enthusiasm. Hewas an accomplished and prodigious writer and he left us shelves of publications to read, study and ponder.

Throughout his life, Legget was outwardly humble but inwardly driven to learn as much as he could about what interested him and to share that knowledge both in print and in the spoken word. He was always generous with his time, his passions, his enthusiasm and his knowledge. He was especially encouraging to younger professionals.

Although born after Queen Victoria died, Legget could be described as one of the last Victorian gentlemen. His son, David, remembers his father “always being in jacket, white shirt, tie and black shoes…even while gardening!” He was hard working and, seemingly, always working. He had a strong code of ethics. He was gentle, generous, polite and patient. He was socially refined and well mannered. He made friends easily and kept them. He wrote and lectured engagingly and well.

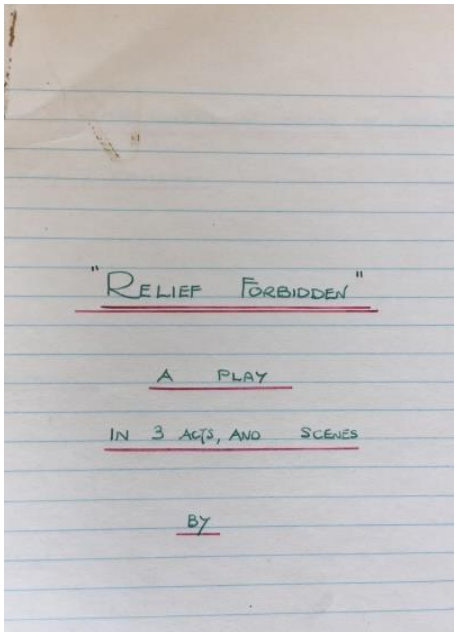
Robert Legget learned from his mentors and in turn, taught and led by his example.

Official NRC photograph taken close to his retirement, with the caption “Robert F. Legget, O.C., Director, Division of Building Research, National Research Council, 1947-1969” (LAC Spec Coll)

Chapter 23: LEGGET'S WRITING AND SELECTED BIBLIOGRAPHY

Legget's Writing

During his lifetime, Robert Legget wrote continuously. He authored, co-authored, edited, co-edited, revised or updated 23 books. In addition, Legget wrote and had published more than 500 papers, book chapters, articles, notes, lectures, introductions, book reviews, discussions, and even two radio documentaries. He started a number of books that he did not complete and submitted one completed manuscript that did not get published. He also completed many manuscripts that never made it to a publisher and others that were never intended for publication. Sometime in the late 1920s or early 1930s, Legget even started to write a play titled "Relief Forbidden," possibly his only fictional work.



Title page of a play that Legget started to write. (LAC 8-16)

The topics of his writing were wide ranging. Based upon a very subjective classification of the primary subject matter of his more than 500 publications, the topics about which Legget wrote and the estimated percentages of publications include the following (the dates indicate the approximate time periods during which Legget published on these subject matters):

- geotechnique and geology: (25%) (1934-1993)
- engineering and geology history: (25%) (1937-1994)
- building construction, standards, codes and fire protection: (15%) (1943-1984)
- engineering in society and education: (10%) (1931-1986)
- general construction: (7%) (1933-1963)
- railways: (7%) (1919-1987)
- general interest and politics: (4%) (1923-1968)
- water power: (3%) (1928-1943)
- conservation: (3%) (1940-1965) and
- underground space: (1%) (1975-1982).

Most of Legget's publications focused on Canada. He was the sole author for the majority of them.

The above estimates do not include his innumerable short news contributions as a 50-year correspondent (1933-1983) for *Engineering News-Record*.

The publications in which Legget's writings were published were much wider ranging than the above categorized subject matters.

According to his son David, Legget's typical method of writing was to first produce a rough handwritten draft (Legget typically used a fountain pen, with either green or blue ink), followed by a second draft typed on a manual typewriter, double-spaced, that he subsequently edited by hand. He would retype a third draft, give it a good proofreading and then submit it.

Legget's typewriters of choice were Underwoods. He had three of them: one at work, one in his study at home and a portable one that accompanied him when he travelled for holidays, such as to Grand Manan Island. Legget never used a computer and its associated word processor. He was not a touch-typist, but could type relatively quickly using two fingers and a thumb on both hands.

Selected Bibliography

This remainder of this chapter lists:

1. all the books that Legget is known to have had published
2. most of his geotechnical and geological publications
3. his "Historical Notes" published in the *Canadian Consulting Engineer*
4. his "History of Canadian Geology" articles published in *Geoscience Canada,* and
5. his major lectures that were subsequently published.

(Because of the difficulty in finding some of these publications, some of the references are incomplete.)

1. Books

1939. *Geology and Engineering,* McGraw-Hill, 650 p. (translated into Spanish in 1950).
1949. (C.P. Disney, first author) *Modern Railroad Structures,* McGraw-Hill, 213 p.
1955. *Rideau Waterway,* University of Toronto Press, 249 p (revised in 1972).
1961. (Editor) *Soils in Canada—Geological, Pedological and Engineering Studies*, University of Toronto Press, 240 p (revised in 1965).
1962. (with T.W. Fluhr) (Editors) *Reviews in Engineering Geology*, Vol I, Geological Society of America, 286 p.
1962. *Geology and Engineering* (2nd Edition), McGraw-Hill, 884 p. (translated into Spanish 1964).
1968-1978. (General Editor) Canadian Building Series, University of Toronto Press.
1971. *Standards in Canada,* Economic and Science Councils of Canada, Information Canada, 248 p.
1971. *Committees: A Working Guide,* National Research Council, NRCC 12306, 58 p.

1972. (with I.C. McFarlane) (Editors) *Canadian Northern Pipeline Research Conference,* National Research Council, Associate Committee on Geotechnical Research, Technical Memorandum 104.
1973. *Cities and Geology,* McGraw-Hill, 624 p (translated into Russian 1976).
1973. *Railways of Canada,* David & Charles, 255 p.
1975. *Ottawa Waterways, Gateway to a Continent*," University of Toronto Press, 304 p.
1976. *Canals of Canada,* David & Charles, 261 p.
1976. (Editor) *Glacial Till: an Interdisciplinary Study,* Royal Society of Canada Special Publication No 12, 412 p.
1977. *Canadian Railways in Pictures,* Douglas & Charles, 96 p.
1979. *The Seaway: 1829, 1959, 1979,* Clark Irwin & Co. 92 p. (in commemoration of 20th anniversary of the St. Lawrence Seaway and the 150th anniversary of the Welland Canal).
1982. (Editor) *Geology Under Cities,* Geological Society of America Reviews in Engineering Geology, Vol 5, 131 p.
1983. (with P.F. Karrow) *Handbook of Geology in Civil Engineering,* McGraw-Hill, 1340 p.
1986. *Rideau Waterway* (2nd Edition), University of Toronto Press, 320 p.
1987. *Railways of Canada* (2nd Edition), Douglas & McIntyre, 255 p.
1988. (with A.W. Hatheway) *Geology and Engineering* (3rd Edition), McGraw-Hill, 613 p.
1988. *The Ottawa River Canals and the Defence of British North America,* University of Toronto Press, 308 p.

2. Most of Legget's Geotechnical and Geological Publications

This list of 129 publications is not necessarily complete. It does not include all of Legget's published introductions, book reviews, abstracts, discussions, consulting reports, etc.

1934. "Geology and Civil Engineering, their relationship with reference to Canada," *Engineering Journal*, Vol 17, pp 431-442.
1936. "Soil Mechanics and Foundation Engineering," *The Engineer*, August 21 and 28.
1936. "The Correlation of Soil Mechanics Studies with the Design and Construction of Retaining Walls," *Proceedings International First Conference on Soil Mechanics and Foundation Engineering*, Vol 1, pp 207-211.
1936. "The First International Conference on Soil Mechanics and Foundation Engineering," *Engineering Journal*, Vol 19, pp 389-391.
1937. "Correlation of Soil Mechanics Studies with Retaining Wall Design," *The Canadian Engineer*, January 19, pp 5-9.
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1938. "The Future of Soil Studies," *Engineering & Contract Record*, March 10.
1940. "Road Officials Show Interest in Soil Engineering," *Roads & Bridges*, Vol 78, No 10, pp 37-38.
1940. "Soil Mechanics in Great Britain," *Engineering Journal*, Vol 23. pp ??.
1941. "Soils and the Engineer" *Proceedings Engineering Conference in Soils for Engineers*, Michigan State College, pp 61-71.

1942. "An Engineering Study of Glacial Drift for an Earth Dam, near Fergus, Ontario," *Economic Geology*, Vol 37, pp 531-?? (reprinted in *Engineering Journal*, Vol 26 (1943), pp. 502-508).
1944. "A Note on the Engineering Significance of the Clay Minerals," *University of Toronto Geological Series*, pp 43-48.
1944. "Stability of Embankments and Fills for Highways," *Roads & Bridges*, Vol 82, No 10.
1945. "An Introduction to Soil Mechanics," *Engineering & Contract Record*, February, pp 70-72 and 168-169.
1945. "Pleistocene Deposits of the Shipshaw Area, Quebec," *Transactions of the Royal Society of Canada*, Section 4, Geological Sciences, Vol 39, pp 27-39.
1945. *Proposed Field Soil Testing Device,* NRC Associate Committee on Soil and Snow Mechanics (ACSSM), Technical Memorandum No 1.
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1946. (with M.G. Bekker) *Fundamentals of Soil Action under Vehicles (Part one),* NRC ACSSM, Technical Memorandum No. 6.
1947. "Numerous reports on various topics," *Proceedings 1947 Civilian Soil Mechanics Conference*, NRC ACSSM, Technical Memorandum No 9.
1947. (F.L. Peckover first author) "List of Special Equipment Available in Canadian Soil Mechanics Laboratories," *Proceedings 1947 Civilian Soil Mechanics Conference*, NRC ACSSM, Technical Memorandum No 9 (App B).
1948. "A Note on Pleistocene Deposits near Three Rivers [Trois Rivières], Quebec," *Transactions of the Royal Society of Canada*, Series 3, Section 4, Vol 42, pp 55-60.
1948. "Soil Mechanics in Canada," *Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering*.
1948. (with F.L Peckover) "Notes of Some Canadian 'Silts'," *Proceedings 2nd International Conference on Soil Mechanics and Foundation Engineering*, pp 96-100.
1948. (with P.A. Harakas) "Grouted fill protects breakwater," *Engineering News-Record*, September 30, pp 1-3.
1949. "Samuel Fortier—a Pioneer in Soil Mechanics," *Engineering Journal*, Vol 32.
1949. (with F.L. Peckover) "Soil Temperature Studies—a Progress Report," *Proceedings 29th Annual Meeting of (US) Highway Research Board*, pp 434-445.
1950. "Special Foundation Problems in Canada," *Proceedings 1950 Soil Mechanics Confer*ence, NRC ACSSM, Technical Memorandum No 19, pp 3.
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In 1999 and 2000, Carl Crawford, Legget's colleague at the DBR, collected and photocopied almost all of the "Historical Notes" written by Legget and published in *Canadian Consulting Engineer* between 1966 and 1994. These are in the Department of Civil Engineering Library, Queen's University in Kingston. Legget taught at Queen's University from 1936-1938 and Crawford was a graduate of Queen's University in 1949. Only 16 of the 108 are identified as being related to geotechnique and/or geology (those highlighted in grey). These 16 are <u>not</u> included in Section 2, above.

No.	Title	Date
1.	The importance of soil tests	Feb 1966
2.	Alexander Graham Bell pioneered space-age structures	Apr 1966
3.	A status symbol of safety	Jun 1966
4.	Scots pioneered framed structures	Aug 1966
5.	Rideau Canal	Oct 1966
6.	Sir Benjamin Thompson -- worker in the kitchen of science	Dec 1966
7.	Father and son innovators in bridge designs	Feb 1967
8.	Materials testing is older than you think	Apr 1967
9.	Controlling the hot air on Parliament Hill	Jun 1967
10.	When air conditioning got on track	Aug 1967
11.	"Modern" studies into soil mechanics go back further than you may think.	Oct 1967
12.	Lessons can be learned from intuitive engineering of the past	Dec 1967
13.	Newcomen paper sheds light on origins of modern steel rolling processes	Feb 1968
14.	Magazine shows engineering was one of Canada's early "arts"	Apr 1968
15.	Arch dam reflects 19th century workmanship	Jun 1968
16.	Ingenuity and simplicity combined in early hydraulic air compressor	Aug 1968
17.	North America could become an island in a metric world	Oct 1968
18.	Coffeehouse meeting led to formation of Institution of Civil Engineers	Dec 1968
19.	Early studies of the properties of snow and ice: Major Williams' early efforts at Quebec City are on record…	Feb 1969
20.	[[missing]]	
21.	Timber strength study won Canada's first accolade	Jun 1969
22.	Nothing new about design-build practices	Aug 1969
23.	Early engineers were progressive thinkers	Oct 1969
24.	Historical fire research: George III had a more than casual interest in this demonstration	Dec 1969
25.	Bridges important to early growth in Montreal	Mar 1970
26.	Early records of neglected pioneers in soil mechanics published	Apr 1970
27.	French used sand drains over 100 years ago	Jun 1970
28.	Canadian ice forced British to experiment	Aug 1970
29.	Cold weather construction—"What's a little bit of snow?"	Oct 1970

30.	Dr. Samuel Fortier pioneered basics of soil mechanics	Dec 1970
31.	Tee-totaling Engineer changed Australia's desert	Feb 1971
32.	Californians owe a lot to Canadian engineering	Jun 1971
33.	Sir Sandford Fleming's muskeg problems: Even Sir Sandford Fleming of the CPR was thrown off his tracks by the muskeg problem	Sep 1971
34.	Shanley's 1856 survey of the Ottawa River	Nov 1971
35.	Geologists contributed much to early engineering work in Canada	Feb 1972
36.	Intercolonial Bridge—a monument to Fleming's fine judgment	Apr 1972
37.	Arctic pioneers displayed ingenuity when faced with permafrost problem	Jul 1972
38.	How Canadians built the Hoosac Tunnel in the Berkshire Hills, Mass.	Sep 1972
39.	How Canadians affected California's Salton Sea	Oct 1972
40.	Age-old permafrost conditions hamper pipeline installations	Jan 1973
41.	The evolution of Portland Cement	Feb 1973
42.	The mystery engineer in charge of the Ottawa River Canals project	Apr 1973
43.	The surprising rarity of Canadian railway tunnels	Jun 1973
44.	Thomas Edison pioneers Canadian prospecting technique	Sep 1973
45.	Wm. Armstrong—Artist, Engineer, Inventor	Oct 1973
46.	Thomas Roy—an unsung hero of early Canadian engineering	Nov 1973
47.	Thomas Roy—an early builder of Toronto	Dec 1973
48.	Another truly great figure in the early days of modem Canadian civil engineering	Feb 1974
49.	Historic military expedition overshadows remarkable northern engineering project	Mar 1874
50.	Major construction program planned to preserve Ottawa's mystery bridge	Apr 1974
51.	Fifty years continuous service of the Saint John Drydock	Jun 1974
52.	Century-old Fort Francis Canal	Jul 1974
53.	Centenary of Ottawa's waterworks	Nov 1974
54.	Only traces remain of the Shubenacadie Canal	Jan 1975
55.	Challenge remains to construct a Chignecto Canal	Feb 1975
56.	The Department of Public Works—over 130 years of dedication	Apr 1975
57.	Another unsung pioneer of Canadian engineering/architecture: Isaac Hildrith	May 1975
58.	Quebec's Victoria Bridge—almost a neglected part of engineering history	Sep 1975
59.	When "reinforcing" was an engineering byword	Jan/Feb 1976
60.	"Inclined planes" play a major role in early waterway travel	Mar 1976
61.	Colonel By—founder and pioneer in the growth of a country	Apr 1976
62.	Hamilton's original waterworks—truly an engineering accomplishment	Jun 1976
63.	A contractor who erects cairns in honor of those with whom he worked	Aug 1976
64.	East coast remains "covered bridge" capital of Canada	Oct 1976
65.	Engineering design of canal advocated as early as 1801	Nov 1976
66.	Sir Percy Girouard—International engineer	Mar 1977
67.	Historical background to building codes	Aug 1977
69.	Foundations make 1856 church a significant structure in Canada	Sep 1977
69.	Canadians in the Corps of Royal Engineers	Nov 1977
70.	Canada's first, and only, tidal lock at Yarmouth, Nova Scotia	Jan/Feb 1978
71.	MacDonald of the Panama Canal	May 1978
72.	The long lost facts of the Grand River are finally found	Aug 1978
73.	Railway survey conflicts cause "mystery" engineer to resign	Feb 1979
74.	First bridge over the Ottawa River proves to be "trustworthy"	June 1879
75.	Conservation Authority to preserve Newmarket Radial Railway Bridge	July 1979
76.	CNR tunnel under St. Clair River still in use	Sept 1979
77.	Sub-surface conditions determine route of Ontario's Murray Canal	Jan 1980
78.	Rice Lake Bridge serves to show the destructive power of ice	Feb 1981
79.	Engineer, architect, actor—F.W. Cumberland rich in talent	Apr 1981
80.	CPR's "temporary" bridges designed to stand the test of time	May 1981
81.	Stephenson's Victoria Bridge still spans St. Lawrence River	Feb 1982
82.	Joseph Hobson—another name to add to our list of engineering greats	Mar 1982

83.	17th century-style building houses modern N.S. power plant	Apr 1982
84.	Ross and Macdonald buildings a tribute to A-E cooperation	Jan 1983
85.	CSA founder Sir John Kennedy, an inspiring Canadian engineer	Aug 1983
86.	Search continues for early engineer's manuscript	Sept 1984
87.	Cedar block construction—a significant building mode	Nov 1984
88.	Trenton, Ont. covered bridge a major river crossing in 1834	Mar 1985
89.	A personal look at three ACEC presidents	June 1985
90.	Brockville tunnel a monument to Canada's own railway fever	Sep 1985
91.	CPR celebrates centenary with driving of last spike	Mar/Apr 1986
92.	Beyond the technical—Sir Casimir Gzowski and Niagara Falls	Mar/Apr 1987
93.	Coteau Canal: Pioneer infrastructure still inspires	May/Jun 1987
94.	Engineering in Canada: Tracing our history pre-1887	Sep/Oct 1987
95.	John Page: Another great pioneer	Mar/Apr 1988
96.	Canada's first observatory erected nearly 150 years ago	Sep/Oct 1988
97.	Wolfe Island Canal: Saving our heritage	Jan/Feb 1989
98.	Sir J.H. Lefroy: Able officer and would-be engineer	Sep/Oct 1989
99.	Royal Alexandra Bridge: 90 years of service	Mar/Apr 1990
100.	Water: A national treasure to be conserved	May/Jun 1990
101.	Royal Sappers build B.C. infrastructure	[[no date]]
102.	Engineering mistakes few but important to progress	Mar/Apr 1991
103.	Study of failures furthers engineering	Sep/Oct 1991
104.	An early professional library	Jan/Feb 1992
105.	Beyond roads and railways: the social life of our first engineers	Sep/Oct 1992
106.	Sarnia's polymer plant: a wartime wonder	Mar/Apr 1993
107.	[[missing]]	
108.	Galbraith: the profession is in his debt	Jul/Aug 1994

4. "History of Canadian Geology" articles published in *Geoscience Canada*

These are <u>not</u> included in Section 2, above.

No.	Title	Date
1.	Sir William Logan	1974 Vol 1 No 1
2.	Early Explorers and Geology	1974 Vol 1 No 3
3.	The Bigsby Medal	1975 Vol 2 No 1
4.	Thomas Roy (? - 1844) an Early Engineering Geologist	1976 Vol 3 No 2
5.	Sir Alexander Mackenzie and Geology	1976 Vol 3 No 3
6.	Early Canadian Record of Glacial Erratics	1983 Vol 10 No 3

5. Major Lectures that were subsequently published

1953. "Resources for Tomorrow: the Engineer's Stewardship," Wallberg Lecture, University of Toronto.
1967. "Soil, its Geology and Uses," Presidential Address, Geological Society of America.
1968. "Man as a Geological Agent," Plenary Lecture, Opening Ceremonies International Geological Congress, Prague, Czechoslovakia.
1969. "Building for Tomorrow," University Lectures No 19, University of Saskatchewan.
1972. "1947-1972-1997: Looking Back 25 years and Looking Forward 25 Years," 25th Anniversary Lecture of the Geological Society of America's Engineering Geology Division.
1977. "Sandford Fleming, Pioneer Engineer," Inaugural Sandford Fleming Foundation Lecture, University of Waterloo.

1977. "The First 150 years of Civil Engineering in Canada," University of Toronto, Department of Civil Engineering.
1977. "Geology and Geotechnical Engineering," Thirteenth Terzaghi Lecture, American Society of Civil Engineers.
1978. "Bownocker Memorial Lecture," Ohio State University.
1979. Two lectures, "Canadian Engineering Achievements" and "The Canadian Engineer's Responsibility to Society: Past and Present," 125th Engineering Anniversary of the University of New Brunswick.
1986. "C.J. Mackenzie and Carleton University," Inaugural C.J. Mackenzie Memorial Lecture, Carleton University.

Chapter 24: SOURCES OF INFORMATION AND REFERENCES

Sources of Information

The primary sources of information for this book are Robert Legget's 1983 unpublished memoir, his eight-page supplement and Lionel Peckover's corrections/clarifications to that memoir. Then, there are also Legget's many books and other publications.

I was provided first-hand memories of Legget during an interview with his son, David Legget, in Toronto, and during an interview with Michael Bozozuk, in Ottawa.

Bozozuk was Legget's last surviving colleague at the National Research Council, Division of Building Research (NRC/DBR). Besides providing me with information on working with Legget for 26 years, he also gave me his "Dr. Legget File" of reprints, background information, news clippings and obituaries that he had been compiling for years.

I was provided with second-hand "Dr. Legget stories" during an interview with Harry Baker, in Ottawa. Harry joined the DBR shortly after Legget retired.

I spent time in the Library and Archives Canada and the National Research Council Archives, both in Ottawa, in the University of Ontario Institute of Technology Archives in Oshawa, ON and in the Faculty of Engineering Office at the University of Toronto. The remainder of my research was done by email and online.

Library and Archives Canada (LAC) in Ottawa has approximately four metres of shelf length of Legget's personal files. These were donated to the archives shortly after his death by David Legget. They are organized into Personal, Writings, Engineering and Geology, History, Associations, Reference Files and Additional Material. (I was surprised to find some of my own correspondence with Legget in his files.) In Legget's LAC files, besides his personal files, there are copies of approximately 300 papers and articles that he authored or co-authored between 1923 and 1993.

The Archival Reference Number for this collection is R4201-0-6-E; the former Archival Reference Number is MG31-J44. LAC's web page for the finding aid for this information is LAC Legget Finding Aid No. 1929. Where I refer to, for example "LAC 4-13," it indicates the LAC box and item number.

LAC Special Collections has approximately 6,000 of Legget's photographs—some prints, negatives and slides. (Oddly, none of Legget's many railway-related photographs are among the photographs.) These photographs are not organized. I refer to these as "LAC Spec Coll." LAC also has a limited number of Legget's memorabilia such as pins and medals. I did not have an opportunity to view these.

In addition, the LAC retains documents related to the Associate Committee on Soil and Snow Mechanics and the Associate Committee on Geotechnical Research. A finding aid for LAC's file number RC 77, 1997/094 is on CGS Virtual Archives web page CGS LAC ACSSM (1945-1965) ACGR (1965-1990).

The National Research Council Archives has less material specifically on Legget, but considerable information on the Division of Building Research and for the period in which Legget was the Director (1947-1969). Specific to Legget, the NRC Archives has some of his original handwritten and typewritten notes and journals and copies of some of his authored books.

Most NRC/DBR publications, many of which have been digitized, are available on NRC web page NRC Publications Archive. Similarly many NRC/DBR photographs are available at NRC Archives Photographs.

The University of Ontario Institute of Technology (UOIT) Archives is a repository for the National Engineering Archives. These archives have "The Robert F. Legget Collection" donated in 2010 by Paul Karrow, Professor Emeritus, University of Waterloo. The collection consists of approximately four metres of shelf length and contains the background materials, including the original photographs and drawings for the *Handbook of Geology in Civil Engineering,* authored by Legget and Karrow in 1983. The collection also contains some textbooks, publications and technical files produced by others that were in Legget's technical library. His technical files, well organized by Legget, are filed by various subjects and/or by geographical areas. The finding aid for this collection is on UOIT web page UOIT R.F. Legget Collection.

The University of Alberta Archives has information on the CGS Geotechnical Heritage Project, a listing of which is on CGS Virtual Archives web page CGS UofA Archives Canadian Geotechnical Heritage Project. It includes a copy of Legget's 1983 memoir and supplement and a few photographs.

The archives of Merchant Taylors' School and the University of Liverpool (both in Liverpool, UK) have dossiers on Legget that provide valuable information on his time as a student at those institutions, 1915-1922 and 1922-1927, respectively.

The Queen's University Archives, Kingston, ON, has some documentation on Legget's two years as a lecturer there (1936-1938). Archival calendars of Queen's University provided information on the Department of Civil Engineering and the courses he taught, as well as where he lived while in Kingston. They are available at Internet Archives Queen's Calendars.

The archival calendars of the University of Toronto provided similar information for the period Legget taught there (1938-1947). They are available at Internet Archives UofT Calendars.

Many of the older issues of the Engineering Institute of Canada's *Engineering Journal* are available at Internet Archives Engineering Journal.

The proceedings of all ISSMGE conferences are available on the ISSMGE web page ISSMGE Conference Proceedings. The Table of Contents of the proceedings of all ISSMGE international conferences, from 1936 to 2001, are available from the University of Massachusetts, Department of Civil and Environmental Engineering web page MIT ISSMGE Conference Proceedings Table of Contents.

In 1997, a short biography of Legget was written by his former colleague, Carl Crawford. This, along with short biographies of Robert Hardy, Ibrahim Morrison and several other influential Canadian geotechnical professionals, was published in a commemorative issue of *Geotechnical News*. This publication is available on CGS web page CGS 1997 An Historical Review.

Tributes to many former Canadian geotechnical professionals, including Legget and Robert Hardy, are on CGS web page CGS Lives Lived.

Some of Legget's obituaries to which I refer are on the Internet. These include ones from the Geological Society of America (by Allen Hathaway), the (US) National Academy of Sciences and (US) National Academy of Engineering (by Alan Davenport), the Royal Society of Edinburgh (by Hugh Sutherland) and *The Independent* and Structures News—a NRC publication (by Lorne Gold). I obtained other obituaries from a few individuals (see Chapter 25).

This being 2020, I also used Wikipedia, Google Maps, Google Street View, Google Earth and many other websites to aid my research. Because website URL's often change, I have simply referred to most of these websites by the organization name followed by "website". I used these sources with caution unless I could verify the information. All websites referenced and listed were accessed in 2019 or 2020.

I first met Legget in 1972 when I was a final-year undergraduate and he was a retired, senior member of the Canadian geotechnical community. We communicated on mutual topics of interest over the years, collaborated on one publication and spoke with each other at various conferences. Just as he had spent a "personal day" with Karl Terzaghi in Montreal, I had the privilege to spend a "personal day" with Legget in Victoria, BC. I was one of the many young professionals who he encouraged and mentored by what he said, wrote and achieved.

General References

The following are some general references (other than those by Legget, which are listed in Chapter 23). These following are references that have been referred to multiple times in the book. Single-use references are provided where they occur.

Crawford, C.B. 1997. "Robert Ferguson Legget and the National Research Council of Canada," *Geotechnical Engineering in Canada, An Historical Review*, published in *Geotechnical News*, Commemorative Issue, October 1997 (Leonoff, C.E. editor), pp 34-38.

Goodman R.E. 1999. *Karl Terzaghi, the Engineer as an Artist,* ASCE Press, 340 p.

Halcrow Group. 1993. *125 Years of Halcrow,* Sir William Halcrow and Partners, 71 p.

Harris, M.C. 1997. "Robert Macdonald Hardy; Engineer, Consultant, Teacher," In *Geotechnical Engineering in Canada, An Historical Review,* published in *Geotechnical News*, Commemorative Issue, October 1997 (Leonoff, C.E. editor), pp 21-26.

Morrison, H.L. 1997. "Professor I.F. Morrison," In *Geotechnical Engineering in Canada, An Historical Review,* published in *Geotechnical News*, Commemorative Issue, October 1997 (Leonoff, C.E. editor), pp 17-20.

VanDine, D.F. and Heinz, H. 2020. "The Canadian Geotechnical Society's 1980s Canadian Geotechnical Heritage Book Project," *Proceedings GeoVirtual2020*, 73rd Canadian Geotechnical Conference, Paper 98.

White, R. 2000. *The Skule Story: The University of Toronto Faculty of Applied Science and Engineering 1873-2000,* University of Toronto Press, 336 p.

Chapter 25: ACKNOWLEDGEMENTS

I had a lot of help in reviewing, editing, annotating and adding photos to Robert Legget's 1983 unpublished memoir, and more help when I decided to expand on the portions of his life not included in his memoir.

First, I thank my wife Donna, who converted the poor quality photocopied and hand-edited copy of Legget's memoir into a Word document so that I could work with it. Optical Character Recognition (OCR) software helped only so much and Donna did the rest. In addition, the time I spent working on this project took away from our time together.

I also thank Heinrich Heinz of Thurber Engineering Ltd and Chair of the Canadian Geotechnical Society's Heritage Committee for his support, encouragement and his thorough technical review, suggestions, questions and his foreword. Heinrich also found Legget's eight-page supplement, Lionel Peckover's corrections/clarifications to the Legget's memoir and several photographs in the University of Alberta Archives.

I owe Craig McInnes a huge thank you for looking at a very early draft of this book, getting me "on track" and then reviewing and editing a later draft. Thank you to Don Shields for his review and his kind words that I have added to the back cover of the book. Mary Rannie and Judith Hunt did a thorough job of reviewing and copy editing, and indirectly gave me a lesson in the English language and, in places, the French language. All was greatly appreciated.

Elizabeth White helped me locate David, Legget's only child, and provided me with a file of Legget's obituaries that her late husband, Owen, had compiled shortly after Legget's death.

I appreciate the time David Legget, now in his mid-80s, spent with me and the personal information he provided about his father. I am pleased to know that David, when he reviewed a draft of the book, learned a lot about his father that he didn't previously know.

I interviewed Michael Bozozuk in June 2019 and, in addition to the information he provided, he gave me a great deal of encouragement for this book project. Unfortunately, he died in January 2020 at the age of 90. It is to him that I dedicate this book.

I thank Harry Baker for recounting some of the "Dr. Legget stories" he heard after joining the DBR shortly after Legget retired, for providing me with other written materials and for taking a few Legget-related photos in the Ottawa area.

Thanks also to those friends, Bill Jeffery and Paul Spafford and their families, who billeted me during my research in Ontario.

Many others assisted. These include France Vachon and Lynn Lafontaine (Library and Archives Canada, Ottawa); Steven Leclair (National Research Council Archives, Ottawa); Brenda Jackson and Robyn Kirkham (University of Ontario Institute of Technology Engineering, Oshawa, ON); Keenen Marie Dixon and Phill Snel (Faculty of Engineering, Communications, University of Toronto); several individuals (who wish to remain nameless) at the City of Ottawa Archives; Diane Downey (Rideau Valley Conservation Foundation, Ottawa); Deirdre Bryden (Queen's University Archives, Kingston); Andy Take, Natalie Arpin and Branna MacDougall

(Department of Civil Engineering, Queen's University, Kingston); Trevor Hildrey (Merchant Taylors' School Archives, Liverpool, UK); Caitlin Fleming and Robyn Orr (University of Liverpool Archives, Liverpool); Val Whinney, a distant relative of Legget's in the UK and Doug Picklyk (Editor, *Canadian Consulting Engineer*, Toronto).

Others who contributed in some way include Michel W. St-Louis (retired geotechnical engineer, Ottawa); Scott McDougall (Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver); Ken Skaftfeld (Trek Geotechnical, Winnipeg); Barry Gough (a historian in Victoria, BC); Dave Gauthier (BGC Engineering Inc, Kingston, ON); James Crawford (NRC, Ottawa); Richard Hunt (Toronto), Heather Jones (University of New Brunswick) and Véronica Boucher (Brechin Group, Ottawa). I apologize if I've missed anyone.

Others who gave me encouragement along the way include Mario Ruel and Michel Aubertin, (President and Executive Director, respectively, of the Canadian Geotechnical Society); David Cruden (Professor Emeritus, University of Alberta, Edmonton) and John Clague (Scientist Emeritus, Geological Survey of Canada and Professor Emeritus, Simon Fraser University, Burnaby).

Last, but not least, I thank Robert Legget for keeping good records and personal files of his life. He made my job a lot easier.

With all the above help, I would hope that I have not made too many mistakes, but undoubtedly there will be some—and they are mine. Please bring any you notice to my attention at vandine@islandet.com.

ABOUT THE BOOK

"What a pleasure it has been to read Doug VanDine's *The Many Sides of Robert F. Legget.* Hours just flew by and I kept reading past my bedtime on a number of occasions. This must have been a labour of love. The attention to detail and the determination with which Doug tracked down additional information convince me of this.

We have Doug to thank for bringing Robert Legget's 1983 unpublished memoir to light and for providing us with a lot of additional interesting information about Legget's life. Legget, one of Canada's fathers of geotechnique, was indeed amazing in so many ways; ways that I did not appreciate those nine years I taught at the University of Ottawa and Legget lived on the other side of the Rideau Canal from me.

The Many Sides of Robert F. Legget is a winner!"

Don Shields, Victoria, BC
Retired geotechnical consultant, professor and Dean of Engineering, University of Manitoba, Don was the president of the Canadian Geotechnical Society in 1977 and 1978.

ABOUT THE AUTHOR

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