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# Education and Professional Recognition of Engineering Geologists and Geological Engineers in Canada and the United States

A.K. Turner
*Dept. of Geology and Geological Engineering, Colorado School of Mines, Golden, Colorado, 80401, USA*

ABSTRACT: Within the United States and Canada, individuals employed in professions that affect public safety and welfare are required to have an appropriate university degree and also to pass an assessment and recognition of their credentials. University educational programs have adjusted to these external legal requirements. In Canada professional recognition results in "licensure," while in the USA it is referred to as "professional registration" or "certification." Canadian and American engineers have been subject to professional recognition procedures since the early 20th Century. The "Geological Engineering" profession developed in the USA to satisfy these legal requirements. Geologists and other scientists have traditionally been exempted from such legal requirements but engineering geologists and hydrogeologists are being increasingly subjected to them. Today, over half the states in the USA and all Canadian provinces and territories except Prince Edward Island and the Yukon require geologists to have professional registration/licensure.

## 1 INTRODUCTION

Within the United States and Canada, individuals employed in professions that affect public safety and welfare – including engineering, medicine, and law, as well as many others – are required to meet two criteria: (1) an appropriate university degree and (2) an assessment and recognition of their credentials enforced by official State (USA) or Provincial/Territorial (Canada) regulations. The assessment and recognition process is slightly different in the two countries, but typically takes the form of two stages of written examinations and an extensive review of documentation defining both education and subsequent working experience. In Canada the process leads to "licensure," while in the USA the process is generally referred to as "professional registration" or "certification." Geologists and other scientists have traditionally been exempted from such legal requirements but those working in applied fields where public safety and health issues arise, including engineering geologists and hydrogeologists, are being increasingly subjected to legal registration requirements.

Several specialty disciplines have emerged in response to the complexity of modern engineering design, especially at the interface between natural earth materials and engineered structures, where naturally occurring materials are used to construct the facility, or where environmental or hazard mitigation considerations arise. This paper focuses on two specialties: "engineering geology" and "geological engineering." Although closely related, and with similar names, these are distinct specializations.

## 2 WHAT IS IN A NAME?

At first glance the terms "engineering geologist" and "geological engineer" appear synonymous. Because the two terms employ essentially the same two words – "geology" and "engineering" – although in reverse order, the opportunity for confusion is great. The word choices may be unfortunate, but the two terms represent distinct, although related, concepts concerning educational and professional endeavors.

## 2.1 *Defining Engineering Geology*

The engineering geologist remains a scientist – albeit a rather applied geologist. The term "Engineering Geology" became widely accepted only as the demand for geological specialists to advise civil engineers developed in the last half of the 20th Century. In response, several universities in the USA and Canada began to offer an "Engineering Geology" option within their science-oriented geological programs.

The engineering geologist applies geologic knowledge and investigative techniques to provide quantitative geologic information and recommendations to engineers for use during design and construction of engineering works, and in related professional engineering practice. Through cooperation, the engineering geologist and the civil engineer share the responsibility for ensuring the public health, safety, and welfare associated with geologic factors that may affect or influence engineering works. In most cases, the public demands that the professional engineers be held responsible for the safety and integrity of their works. Thus the engineering geologist may be considered as a specialist advisor to the design team, and may hold a position similar to an architect or other design specialist.

The scope of engineering geology practice has expanded beyond its original close connection with civil engineering. Many engineering geologists currently work closely with land-use planners, water resource specialists, environmental specialists, architects, public policy makers, and property-owners, both public and private, to prepare plans and specifications for a variety of projects that are influenced by geologic factors, involve environmental modifications, or require mitigation of existing or potential effects to the environment (Mathewson 1982).

## 2.1 *Defining Geological Engineering*

A geological engineer is trained as an engineer – but an engineer with a broad understanding of applied geological science.

"Geological Engineering" developed in the early 20th Century in the USA in response to a combination of technical opportunities and the established legal processes for obtaining professional engineering registration. Because the minerals and petroleum industries required increasing numbers of specialists with engineering training combined with geological knowledge, a number of universities and mining schools in the western United States began to offer engineering programs leading to a degree in "Geological Engineering" (Turner 2005).

Most of the early geological engineers did not work on civil engineering projects; they were more likely to work on minerals exploration and exploitation projects with mining engineers, or on petroleum exploration and production projects with petroleum engineers. In the latter half of the 20th Century, major civil engineering projects following World War II placed new demands for specialists to work with civil engineers. In response to this new demand, many of the Geological Engineering academic programs began to provide "options" – usually three, with titles such as "Petroleum Exploration", "Minerals Exploration" and "Engineering Geology."

Many recent geological engineering graduates are now employed in civil engineering applications and ground water evaluations. Graduates may continue to specialize with more advanced degrees in such areas as geotechnical engineering, rock mechanics (for tunneling and underground construction), hydrogeology, contaminant transport to evaluate ground pollution issues, or various geohazard mitigation studies, including landslides, earthquakes, or floods (Higgins 1991).

## 3 UNIVERSITY EDUCATION

In the United States and Canada, university education programs for science and engineering are similarly structured. Undergraduate training nominally extends over four years and results in the awarding of a "Bachelor's" degree. Initial graduate studies are nominally designed to extend over an additional two years and lead to a "Masters" degree, which may or not involve a thesis research component.

Several universities offer options for obtaining both a Bachelors and a Masters degree in a five-year accelerated program. Employers and individuals accept the need and advantages of further specialized education offered by Masters Programs, and many individuals return for a Masters program with a focus on an area of their interest a few years after their undergraduate

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program was completed, rather than continuing directly from a Bachelors to a Masters program. Advanced graduate research programs, leading to a PhD, are offered in both geological engineering and engineering geology by several universities. However, the number of doctoral students in these areas is relatively small, since most of the industrial employers do not see the need for such a level of specialization.

### 3.1 *Undergraduate Education in the USA*

Most universities offer instruction in two semesters – the "Fall Semester" extends from late August until mid-December, and the "Spring Semester" begins in January and ends in May. Each semester provides 15 weeks of instruction. Individual subjects are assigned "credit hours" with 1-credit-hour corresponding to 1-hour of lecture instruction, or 3-hours of laboratory activity, per week; most courses are established at "3 credit hours." Undergraduate degrees are generally defined as "Bachelors of Science (BS)" and require between 125 and 145 credit hours of specified coursework; with the majority of programs requiring about 135 credit hours for graduation. With a program extending over four years (8 semesters), a student a studies five subjects simultaneously in a typical semester.

### 3.2 *Undergraduate Education in Canada*

Canadian universities operate under a variety of instructional systems that reflect both American and European norms. Canadian universities offer the majority of their classes in a September-May schedule, with two 13-week instruction periods ("terms"). Many classes are completed within a single term, but some classes extend over the entire "year" of two terms. Credit is assigned at 0.5 credits for a single term class, and 1.0 credit for a full-year (two term) class.

At these universities most programs of study require 20 credits for graduation, with the credits assigned among introductory and advanced topics. All engineering programs follow a four-year curriculum and graduates receive a "Bachelor of Science (B.Sc.)" or "Bachelor of Applied Science (B.A.Sc.)" degree. Some university science faculties offer three-year "Bachelor of Science (B.Sc.)" degrees, which require only 15 credits to complete, and four-year "Honours Bachelor of Science H.B.Sc.) degrees that require 20 credits. However, the three-year degrees are increasingly considered to provide inadequate preparation and are being discontinued at several universities. Several Canadian universities, especially those in the western regions, follow the American credit-hour system, and require 135 credit hours over four years for graduation.

### 3.3 *Review and Accreditation*

Undergraduate university education, especially in science and engineering, is widely perceived by the general public as providing basic training in fundamentals and skills that allows graduates to gain professional employment. This provides a strong link between university curricula and the requirements of the professional marketplace. Thus, universities accept and encourage the external review and "accreditation" of their programs. In the competition for new students, these accreditations are presented to the students (and their parents) as assurances that the university education will lead to rewarding careers. There are several forms of accreditation. Regional associations accredit the entire university in terms of basic educational standards. Individual degree programs are reviewed and accredited by external professional organizations.

#### 3.3.1 *Accreditation in the USA*

In the United States, the Engineers' Council for Professional Development was established in 1932 to evaluate university engineering curricula at the undergraduate level. This became the Accreditation Board for Engineering and Technology (ABET) in 1980. ABET is now a federation of 32 professional engineering societies covering the full spectrum of engineering specialties. The Society of Mining, Metallurgy, and Exploration (SME), formerly the Society of Mining Engineers, is the sponsor society for geological, mining, and geophysical engineering programs (Elifrits 2002, Higgins 2003).

Discussions to expand ABET accreditation into associated fields began in the 1980's, and this has occurred in some areas, such as for computer science and some applied sciences (Elifrits 2003, Herrick 2003). The American geological community has remained divided on the merits of professional registration; many engineering geologists and hydrogeologists working in the public arena favor registration, while geologists working in minerals and petroleum exploration, or in research positions are generally opposed. Thus, at present, there is no accepted accreditation procedure for geology programs within the United States (Burns 2002, 2003, Schmitz 2003, Williams 2003).

#### 3.3.2 *Accreditation in Canada*

In 1936 the 12 provincial and territorial engineering associations formed the Canadian Council of Professional Engineers (now "Engineers Canada") as their national coordinating organization. In 1965, Engineers Canada established the Canadian Engineering Accreditation Board (CEAB) to accredit undergraduate engineering programs. Although the geological engineering approach was not widely adopted in Canada, several geoscience departments at Canadian universities either partially or entirely joined the Faculties of Applied Science (in other words – engineering). This resulted in these universities offering "geological engineering" programs that are evaluated and accredited by the CEAB.

In 1997, the majority of Canadian provinces and territories began to regulate the practice of geoscientists and the self-regulating professional associations model used by engineering was followed. In most cases, the existing engineering association expanded to meet the broader areas of practice. Coordination of these efforts resulted in the establishment of a national organization – the Canadian Council of Professional Geoscientists (CCPG) – that represents the interests of geologists in all provinces and territories except the Yukon and Prince Edward Island (CCPG website).

The CCPG established the Canadian Geoscience Standards Board (CGSB) as a standing committee to provide guidance to the constituent associations of CCPG on matters relating to professional qualifications and practice. While the CGSB encourages the adoption of common academic standards for geoscience programs, unlike the CEAB and engineering programs, the CGSB does not accredit individual university programs of study. Thus Canadian universities continue to offer a variety of undergraduate geoscience programs.

### 3.4 *Typical Geological Engineering Education*

Because of the long-existence and rigorous application of the accreditation programs by ABET and the CEAB, the undergraduate geological engineering programs in the USA and many of the Canadian geology programs produce graduates with very similar credentials – their curricula have to meet consistent standards, goals, and objectives. There are of course regional differences, and some individuality in each university. A typical geological engineering program that satisfies ABET accreditation criteria contains five components shown in Table 1.

Table 1. ABET Geological Engineering Curriculum Requirements (Higgins 1991)

| Component | Importance ( % Total Program) |
|---|---|
| 1. Mathematics/Basic Science | 25% |
| 2. Engineering Science | 25% |
| 3. Engineering Design | 12.5% |
| 4. Humanities/Social Science | 12.5% |
| 5. Competency (in computers, scientific laboratory investigations, written and oral communication) | 25% |

At least 20% of the entire program must be devoted to geology, including physical geology, mineralogy, petrology, structural geology, stratigraphy and sedimentation, and elements of geophysics. Required mathematics includes calculus through differential equations, and statistics or numerical analysis. The basic science topics include at least two courses in chemistry, two in physics, as well as the basics of geology included above. The engineering science component includes statics, mechanics of materials, fluid mechanics, soils and/or rock mechanics, hydrogeology, hydrology, and certain aspects of applied geology subjects.

A typical four-year program devotes much of the first two years to the mathematics, basic science, and some engineering science subjects, along with several of the "competency" components and humanities and social science requirements. The third year is devoted to a combination of engineering science and applied geology subjects.

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An extensive period of field work (usually about 6 weeks) is required at the end of the third year (Williams 1991). The fourth year focuses on the design experience, usually with "capstone" courses that analyze open-ended problems developed to consider economic and social factors along with geological and engineering criteria (Higgins 1991).

### 3.5 *Typical Engineering Geology Education*

Because undergraduate geology programs in the USA have not been subjected to the same type of long-term national accreditation procedures as have the engineering programs, their content is much more variable. Most such programs do not offer any "engineering geology" courses or emphasis, although some offer a limited exposure to "environmental geology" subjects. Graduates from these programs are not prepared to become engineering geologists.
A few universities offer engineering geology, often as an "option" within a broader geology curriculum. An individual student can select this option by choosing a preferred sequence of courses. Although these programs can be quite variable, a "typical" engineering program might be structured according to the five components shown in Table 2, which is based on curriculum data provided by West (1991).

Table 2. "Typical" Engineering Geology Curriculum (West 1991)

| Component | Importance ( % Total Program) |
|---|---|
| 1. Mathematics/Basic Science | 25% |
| 2. Engineering Science | 14% |
| 3. Basic Geoscience | 17% |
| 4. Applied Geoscience | 16% |
| 5. Humanities/Social Science | 28% |

Comparison of the importance percentages shown in Tables 1 and 2 demonstrates the similarities and differences of geological engineering and engineering geology education. Both have 25% effort on mathematics and basic science courses. Engineering geology has 33% emphasis on geology subjects (17% basic geoscience plus 16% applied geoscience) compared to about 20% required for geology subjects by the geological engineering ABET criteria. Geological engineering has more engineering science (25%) compared to engineering geology (14%). Engineering geology does not include any significant amount of engineering design subjects, which account for 12.5% of the geological engineering curriculum, although some similar topics are no doubt included in the applied geoscience component of engineering geology. The engineering geology program has a much larger emphasis on humanities (28%) compared to geological engineering (12.5%), although the "competency" component of geological engineering may partially address the difference in emphasis.
Thus, overall, the two programs are not so very different in their educational background. Thus graduates from either program should be able to perform similar professional tasks (Heath 2002). From a technical standpoint, this is undoubtedly true. However, issues related to the definition of professional recognition and legal responsibility result in some differences in the professional activities of geological engineers and engineering geologists (Higgins 1991).

## 4 PROFESSIONAL RECOGNITION

In both the USA and Canada the professional registration/licensure of engineers was legislated at the state/provincial level in the early 20th century, largely in response to a perceived need to protect the public.

### 4.1 *Geological Engineering Professional Registration in USA*

Legal responsibility for the professional registration of engineers of all disciplines is delegated to "Professional Engineers Registration Boards" in each State. Although requirements and regulations do vary by state, most state boards require applications for "registration" as a "Professional Engineer," designated by the initials "PE", to:

a) Obtain a university education from an engineering program accredited by ABET,
b) Pass a "Fundamentals of Engineering (FE)" exam, and
c) Pass a "Principles and Practice in Engineering (PE)" exam after several of years of experience.

Geological engineering graduates from ABET-accredited programs meet the first of these criteria and thus are eligible to ultimately become a

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registered professional engineer, after successfully completing the FE and PE exams.

The National Council of Examiners for Engineering and Surveying (NCEES) develops, scores, and administers the FE and PE examinations for the engineering and surveying licensing boards representing all states and territories. The exams contain multiple-choice questions and are rigorously subjected to statistical checks to establish their validity (NCEES website). The FE exam is eight hours long and is split into two four-hour sessions separated by a lunch break. The morning session is a 120-question general exam taken by all candidates, while the afternoon session consists of 60 questions related to one of seven disciplines: chemical engineering, civil engineering, environmental engineering, electrical engineering, mechanical engineering, industrial engineering, or general engineering. The FE exam is “closed-book” – no reference materials are allowed and only approved models of calculators are allowed.

The PE exam also lasts eight hours divided into four-hour morning and afternoon sessions. A large number PE exams have been developed for a variety of engineering and surveying areas of practice (NCEES website). However, there is no specific geological engineering PE exam, so candidates are forced to select either civil engineering or mining and mineral engineering exams. Both cover topics that are outside the normal practice of geological engineering.

Successful completion of the FE and PE exams allows registration as a professional engineer. But the registration is only valid for an individual state, if an individual wishes to work in multiple states, then multiple registrations are necessary. The process of obtaining and maintaining multiple registrations can be complex and expensive.

Many laws and regulations stipulate that engineering design documents be signed by a professional engineer, even in cases where geological aspects are involved that may be outside a typical engineer’s area of competency! This gives distinct advantages to geological engineers over engineering geologists, since the geological engineer with his PE registration has definite legal authority.

### 4.2 *Competing Approaches to Geologist Registration in the USA*

Professional registration of Geologists within the USA has been debated for about 20 years. Geologists employed in petroleum and mineral exploration have generally been opposed to calls for registration, while geologists involved in engineering, hydrogeology, and environmental projects, where public health and safety issues are readily apparent, have generally favored registration efforts. State-by-State registration of geologists, following the engineering ABET model appears to be the generally accepted method. Arizona was the first state to legislate registration of geologists (Greenslade 2002). California was an early proponent of geologist registration, and has one of the largest programs. Currently, 26 out of the 50 states require registration of geologists. State boards of registration, independent of the engineering boards, supervise the registration procedures in their state, and these boards cooperate through the National Association of State Boards of Geology (ASBOG).

ASBOG supervises the development and scheduling of two examinations – a “Fundamentals of Geology (FG)” exam and a “Practice of Geology (PG)” exam. The state boards of geology administer these exams; ASBOG develops and scores them. Details of the FG and PG examination procedures are provided in reports by Williams (2002, 2003), by Schmitz (2003), and on the ASBOG website listed in the references.

In those states that require professional geological registration, many regulations now give registered professional geologists approval authority for appropriate design documents, equivalent to the authority granted to professional engineers, but situations do arise where there are disputes. In states lacking geologist professional registration requirements, engineering geologists must act as specialist advisors to a design team headed by an engineer who makes the final legal approvals.

The ASBOG examinations have been developed to meet the expectations of the state geological registration boards which are largely concerned with public safety issues. The questions reflect the importance of tasks performed by engineering geologists and hydrogeologists. Pass rates for candidates have remained quite low – the average success rate for the fundamentals exam is 57%,

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and for the advanced (practice) exam, taken some years later, 68%. Neither shows any strong trend toward improvement (Williams 2003). These data tend to suggest that the consistency and quality of undergraduate geological programs in the USA is not adequate for many wishing to undertake engineering geology or hydrogeology careers. This has been used as an argument in support of registration of geologists in additional states that currently do not require registration.

The American Institute of Professional Geologists (AIPG) also provides a "certification" of geologists, giving those approved the use of the title "Certified Professional Geologist" (CPG). This certification is conducted by peer review of credentials without any examinations. It has no legal standing in those states requiring registration, but does provide individuals with some "national" credentials that may assist them in providing expert testimony and in similar situations.

### 4.3 *Registration Issues in Canada*

In Canada, the provinces (and territories) also enacted legislation in the 1920's to provide professional recognition of engineers, but these designate appropriate professional associations or societies as the operating authority under the concept of "self-governance." Canadian engineers place the initials "P.Eng." after their names, in contrast to the "PE" designation used in the USA. The geoscience professions remained unregulated until, in 1997, Bre-X Mining Ltd., a Canadian mineral exploration firm, caused a major stock market crisis when it reported a major Indonesian gold deposit that was subsequently shown to be based on fraudulent mineral samples. The majority of Canadian provinces and territories responded by regulating the practice of geoscientists. The self-governance model used successfully by the engineering and other professions was adopted. Professional geologists place "P.Geo." after their names. However Alberta, which separately designates geologists and geophysicists, uses the designations "P.Geol." and "P.Geoph." to define the specializations. In most provinces, a single joint association supervises the licensure of both engineers and geologists.

Ontario and Quebec have separate associations to manage the professional recognition of geoscientists and engineers. In Ontario, the dual system developed only after a proposed joint approach was protested by a group of engineers. In spite of some such occasional evidence of friction, interactions are generally good and some individuals hold dual designations of geologist and engineer.

The various associations coordinate their efforts at the national level through the Canadian Council of Professional Engineers (CCPE, now "Engineers Canada") and the Canadian Council of Professional Geoscientists (CCPG).

Thus, in contrast to the USA, a considerable percentage of Canadian geoscientists have professional registration. By 2006, over 7,700 individuals had professional geologist registration, and this was expected to increase to almost 10,000 individuals within a short period of time (CCPG website).

This is largely due to regulations requiring any geoscientist involved in mining and exploration to be a "qualified person." Court cases have defined this as requiring an individual to belong to a self-regulating professional organization and to have a minimum of 5-years of experience (Pinsker 2002). Many individuals working in engineering, hydrogeology, and environmental topics hold dual registrations as engineers (P.Eng.) and geologists (P.Geo.). This is made easier when a single association supervises both designations, as is the case in the majority of provinces and territories.

A 2005 ASBOG Task Analysis Survey of approximately 2800 American and 700 Canadian geologists demonstrated differences between Canadian and US primary areas of professional practice. Although the ASBOG examinations have not been extended to Canada, those responsible for developing the exams conducted a survey to establish the degree of consistency in geological practice throughout North America (Warner & Warner 2005). In the USA, 68% of the respondents indicated that hydrogeology and environmental chemistry was their primary area, compared to only 19% of Canadian respondents who reported this as their primary area. In contrast, economic geology and energy resources was the primary area for 37% of Canadian geoscientists; while only 9% of US geologists selected this area as their primary interest.

## 5 CONCLUSIONS CONCERNING PROFESSIONAL REGISTRATION

In North America, the professional registration of engineers has been legislated at the state/provincial level since the early 20th century and has been accepted as needed to protect the public interests. The case for an equivalent registration of geologists has not been so clearly accepted, and in fact there has been considerable opposition to such registration by many geologists. Major constraints are the lack of public acceptance of the need for registration, the lack of "official" legal standing, the objections of many geologists who see registration as restricting their mobility and freedom to conduct studies, objections by other professions, and competition among professional societies for authority to provide and supervise such registrations.

In the USA, procedures to register engineers and geologists are administered quite independently by distinct official boards of registration. While all states have engineering boards, only about one-half the states have geology boards. In Canada, the provincial legislatures delegate the registration process to professional associations, and in the majority of the provinces a single association supervises the registration of engineers and geologists. The relatively rapid recent acceptance of the need for professional registration by most Canadian geologists reflects the need to establish credentials as a "qualified person" by those geologists involved in mining and exploration activities, imposed by the new regulations developed after the 1997 Bre-X scandal (Pinsker 2002).

In the light of these developments, it is perhaps not surprising that the concept of "Geological Engineering" should arise in the USA, allowing engineers with specific geological knowledge and skills to become registered as engineers, and for selected similar programs to have developed in Canada. While geologist registration is only slowly becoming accepted in many parts of the United States, in Canada those geologists desiring registration and having the requisite skills and experience can now obtain registration as geologists, as engineers, or both.

The requirements to have multiple registrations in several states or provinces in North America in order to undertake projects at several locations impose time and cost constraints on individual engineers and geologists, and their employers. Individual Canadian geologists have been particularly affected by the barriers to their mobility within Canada (Boivin 2006). While legal difficulties make it extremely difficult for most provincial and territorial associations that are responsible for engineers and geoscientists to create simple administrative solutions, Ontario and Quebec, with separate geoscientist associations, were able to complete a bilateral mobility agreement in 2003 (Boivin 2006). Further work on establishing a national geoscientist mobility agreement for all of Canada is currently underway, largely because the Canadian government has passed an "Agreement on Internal Trade" that mandates that all regulated professions must be compliant with its mobility standards by April 1, 2009

International trends, especially the increased globalization of markets for consultation services as well as goods, have placed new pressures on the existing professional registration procedures. Only limited reciprocity arrangements exist between Canada and the United States, in spite of the regulations embodied in the North American Free Trade Agreement (NAFTA). For engineers, some Canadian provincial associations and US states adjacent to the Canadian border do provide limited exchange authorizations with temporary licensure approvals for trans-border projects.

The national organizations in Canada and the United States that have coordination authority among the provincial associations and state boards for geoscientists, CCPG and ASBOG, have recently entered into a cooperation agreement. This recognizes that the ASBOG and CCPG mandates and objectives with respect to the professional practice of the geological sciences are similar and that the practice of the geological sciences transcends national borders. It does not yet provide an easy process for individuals to practice legally in the two countries. Details are available at http://www.ccpg.ca/mobility_agreements/national_association_state.html.

## 6 A LOOK TO THE FUTURE

There is a strong demand for engineering geologists and geological engineers to solve society's needs and desires for a more livable environment. Certainly, new and ever more challenging environmental issues will make the design and construction of new transportation and other facilities depend even more on an accurate prediction of geologic conditions. The increasingly sophisticated designs depend for their success on the involvement and acceptance of the geological engineer and engineering geologist (Turner 2005). In North America, the enrollment of students in engineering and science, especially geoscience, has been falling for several years. The recent increase in oil prices has resulted in a marked increase in the numbers of students considering petroleum-related careers, but potential students have not yet similarly identified the demands from the mining and geotechnical communities. This drop in enrollment is partly a function of demographic trends, but it also is a reflection of the disinclination of students to choose "tougher" classes, and those in narrow "specialty" fields. At the same time, economic pressures faced by many universities encourage the elimination of smaller "specialist" or "elitist" and high-cost programs and departments. A number of geology and geological engineering programs have been eliminated in the past decade, and several more are at risk. This is occurring in spite of expanding employment opportunities and the recognition of the need for such specialists by potential employers.

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